

## RISKS AND RETURNS TO EDUCATION OVER TIME\*

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We model education as an investment in human capital that, like other investments, is appropriately evaluated in a framework that accounts for risk as well as return. In contrast to dominant wage-premia approach to calculating the returns to education, but which implicitly ignores risk, we evaluate the returns by treating the value of human capital as the price of a non-tradable risky asset. We do so using a life-cycle framework that incorporates risk preferences and earnings risk, as well as a progressive income tax and social insurance system. Our baseline estimate is that a college degree provides a \$440K dollar increase in annual certainty-equivalent consumption. Although significantly smaller than traditional estimates of the value of education, these returns are still large enough to offset both the direct and indirect cost of college education for a large range of plausible preference parameters. Importantly, however, we find that accounting for risk reverses the finding from the education wage-premia literature regarding the trends in the returns to education. In particular, we find that the risk-adjusted gains from college completion actually decreased rather than increased in the recent period. Overall, our results show the importance of earnings risks in assessing the value of education.

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## I. INTRODUCTION

Trade-offs between risk and return play a central role in standard financial and economic models of investment in physical capital. In contrast, a very large literature on investment in human capital, i.e., the returns to education, has largely focused on average returns without giving full consideration to risk. The standard approach in the returns to education literature, which traces to Mincer's (1974) seminal paper, is to regress wages (or other dollar-denominated outcomes) against the level of education, controlling for demographic and job characteristics. Such an approach does not capture variation in the value of education that arises from other life-cycle factors, including the concavity of utility over consumption, differences in unemployment risk or earnings volatility by education, or the progressive tax and social insurance system that may dampen the returns to education. In this paper, we examine the returns to education in a utility-based model that accounts for several important life-cycle factors, and in particular we study how these risk-adjusted returns have changed over time.

Valuing human capital is equivalent to computing the price of a non-tradable risky asset: we need an estimate of the expected dividends and an appropriately risk-adjusted discount rate. We estimate the expected dividends (earnings) from micro-data and we compute the discount rate from a structural lifecycle model of consumption and saving decisions (see, for example, Carroll 1997, Gourinchas and Parker 2002, Hubbard, Skinner and Zeldes 1995).<sup>1</sup> Because it is well known that education reduces the probability of unemployment and is also associated with changes in earnings volatility (see Moffitt and Gottschalk 2012 for a recent review), we incorporate these factors into our analysis. Specifically, we model the income process by following the approach of MaCurdy (1982) and Abowd and Card (1989), combining a deterministic component (capturing the hump shape of life cycle earnings and retirement income) and two random components that capture both transitory and permanent (e.g., career) uncertainty. We estimate the earnings process—differentiated by education level—using the 1968-2011 waves of the

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<sup>1</sup> Huggett and Kalpan use a similar approach to compute “the value of a man”. Here we focus on the differential values by education and the risk-return trade-off for human capital. Padula and Pistaferri (2005) use a utility function to compute the expected discount value of alternative income streams based on different education levels, effectively under the assumption that agents consume their current income every period.

Panel Study of Income Dynamics (PSID). For each education group, our model accounts for this stochastic labor income process, the probability of unemployment, the receipt of unemployment insurance income, a progressive income tax system, and a progressive Social Security system for providing benefits in retirement. We take a conservative view and consider all heterogeneity across individuals as driven by ability or other unobservable individual-specific characteristics, thus classifying only within-individual income shocks as risk.

Before studying how the gains from education evolve over time we first present and discuss the average gains over the full sample. Expressing in terms of lifetime certainty equivalent (i.e., risk-adjusted) wealth, we find that the typical high school graduate will enjoy a level of lifetime consumption \$238K dollars (after-tax and valued in 2010USD) higher than those who did not finish high school. In other words, an individual with our baseline preference specifications (relative risk aversion of 2, and discount factor of 0.99) should be willing to pay as much as \$238K to attend and complete high school. The gains from college completion are even larger: the (risk-adjusted) present value of human capital of the average college graduate is over \$441K dollars higher than the human capital of an otherwise identical high school graduate. This corresponds to a 42% increase in annual certainty-equivalent consumption, and it is substantially more than the typical cost of a college education. While substantial, these gains are significantly lower than many estimates of the returns to education that are based on average returns (and which are frequently cited in the popular press).

Consistent with our estimation results, high school graduates have lower volatility of income shocks and a very similar probability of unemployment relative to agents without high school education. Therefore, a high school degree both provides an increase in average lifetime income and a decrease in the volatility of potential outcomes. In contrast, the gains from college are slightly smaller when one accounts for earnings uncertainty. College graduates have a much lower probability of unemployment than do high school graduates, which increases the value of education. However, college graduates also face a much more skewed distribution of lifetime earnings (i.e., they experience very high career earnings

heterogeneity), so assigning them the average income over-estimates the value of college education for a risk-averse agent.

The importance of the utility-based calculations becomes even clearer when we compare the certainty equivalent gains for different values of the preference parameters. As previously discussed, high school graduates benefit both from a higher average income, and from a reduction in earnings risk. Naturally, the value of the second component will depend on the agent's risk preferences. Therefore, we should expect that the gains from education will vary across the population. In fact we find that, for reasonable preference parameters, the welfare gains from high school can vary from about \$223K (risk aversion of 1 and discount factor of 0.99) to nearly \$272K (risk aversion of 4 and discount factor of 0.97). Similarly, the gains from college completion vary from \$226K to \$589K. The reverse pattern is visible for college graduates: the more risk-averse agents will assign a lower value to college education, since it implies a much higher dispersion of outcomes than a high school degree.

We also compare our measured gains with estimated costs of education. Here we include both direct costs (tuition plus room and board) and indirect cost (foregone wages). For our lower (upper) bound estimate on the costs the net gains from college enrollment vary between \$96K (\$16K) and \$459K (\$379K). Once again we conclude that there is a large dispersion in values, and therefore the gains from education depend significantly on individual preferences, once we take into account for risk.

Having discussed the determinants of the risk-adjusted gains to education we can now examine how these have evolved over time. It is well-documented in the labor economics literature that education wage premia, especially those for college degrees, increased substantially in the 1980s and again in the 1990s (see, for example, Autor, Katz and Kearney 2008, Card 1999, Goldin and Katz 2007, Katz and Murphy 1992, Katz and Autor 1999, Lemieux 2006). In addition, it has been shown that earnings volatility increased in the 1980s (Cunha and Heckman 2007, Gottschalk and Moffitt 1994, Moffitt and Gottschalk 2012). Motivated by this evidence, we divide our sample in three different time periods: 1969-1980, 1981-1990, and 1991-2011 and repeat our analysis for each. Consistent with the previous literature, overall we find higher earnings volatilities in the 1980s than in the 1970s. The patterns in the

1991-2011 period are more complex: we find that transitory earnings volatilities have increased over this period, but that the volatility of permanent earnings shocks (career uncertainty) increased only for college graduates. Interestingly, we observe noticeable reductions in the average lifetime earnings for both high school graduates and high school dropouts from 1969-1980 to 1981-1990. The earnings stayed largely the same for these two groups between 1981-1990 and 1991-2011. For college graduates, there was a modest decrease in average earnings in the 1980s followed by an increase in the 1991-2011 period.

As a result, if we compute the gains from education as the ratio of the present value of average lifetime earnings for higher versus lower education groups, we conclude that the gains from college have increased steadily over time, consistent with the wage premia literature. Under the same calculations, the gains from high school have remained relatively constant in the 1980s and increased afterwards. However, when we compute the risk-adjusted certainty equivalents we observe very important differences, particularly in the later sample period. For college graduates, we find that the certainty-equivalent gain is significantly *lower* in the 1991-2011 period, even though the average expected income is significantly higher. The explanation for this striking difference lies in the very large increase in the dispersion of earnings for college graduates. In other words, average present value calculations ignore the impact of the concurrent substantial increases in the volatility of college graduates earnings (namely in their career heterogeneity). Even though their average income is higher, most college graduates will earn much less than this average number and, even if they are mildly risk averse, this is enough to make the distribution of future earnings in the 1991-2011 period less valuable than the one in the 1981-1990 period. On the other hand, for high school graduates, the gains in percentage terms are actually much higher than the average present value calculation would suggest. This is driven by the large increase in income risk for those with no high school education, relative to a much more modest increase for those with high school degrees.

Finally, we also study gender differences in the returns to education, although this analysis is subject to some important caveats that we discuss later. Across all education levels the volatility of income shocks is much higher for women than for men, while the average lifetime present values are

much higher for men than for women. On net, the gains from high school degree are much higher for women than for men (88% versus 22%), due both to larger increases in average lifetime income and to a more significant reduction in earnings uncertainty. For college the gains are also higher for women, but the differences are smaller (55% versus 39%). In other words, education helps to reduce the gender gap in lifetime earnings.

In contrast to the lion's share of the literature on returns to education, this paper is not focused on measuring causal effects of education on earnings. Rather, the aim of this paper is to show that, for a given set of age-earnings profiles by education level, accounting for preferences, earnings volatility, and fiscal parameters (e.g., taxes) have important implications for how we think about the returns to education. In doing so, we provide specific numerical estimates of the impact using longitudinal data from the PSID. We discuss below the ways in which our specific numerical estimates may be biased and why we believe such biases are likely to be small. This paper proceeds as follows. In Section II we describe the life-cycle model used for the certainty equivalent calculations and the labor income process. In Section III we describe the data used in the estimation of this income process, and in Section IV we present the estimation results. Section V reports the gains from education in a baseline case, while in Sections VI, and VII we study how these vary across time and by gender. Finally, our concluding remarks are offered in Section VIII.

## **II. LIFE CYCLE MODEL AND LABOR INCOME PROCESS**

We begin with a standard life-cycle model of consumption and savings decisions along the lines of Gourinchas and Parker (2002), Carroll (1997) or Hubbard, Skinner and Zeldes (1995).

### *A. Preferences*

Time is discrete and  $t$  denotes adult age, which, following the typical convention in this literature, corresponds to actual age minus 21. Each period corresponds to one year and agents live for a maximum

of 79 ( $T$ ) periods (age 100). The probability that an agent is alive at time  $(t + 1)$  conditional on being alive at time  $t$  is denoted by  $p_t$  ( $p_0$  equal to 1). Lifetime preferences are given by a standard time-separable power utility function:

$$(1) \quad U = E \left[ \sum_{t=1}^T \beta^{t-1} \prod_{s=0}^{t-1} p_s \frac{(C_t)^{1-\gamma}}{1-\gamma} \right]$$

where  $\beta < 1$  is the discount factor,  $C_t$  is the level of date- $t$  consumption, and  $\gamma > 0$  is the coefficient of relative risk aversion.

We consider the same starting age (22) for all education groups because, in a utility-based model, including a different number of years effectively changes the functional form of the utility function and invalidates comparisons across education groups. Therefore we consider income earned at earlier ages (by those with lower education levels) as an opportunity cost of education to be treated in the same manner as the direct cost of education (i.e., to be netted against the computed gains to education).

### *B. Income and Wealth Accumulation*

Agents work during the first 44 (denoted  $K$  in equations [3] and [5] below) periods of their adult lives, and retire at age 66.<sup>2</sup> Before retirement, agents supply a fixed amount of labor each period, and earn labor income ( $Y_t$ ) that will depend on their own productivity. Labor productivity is a function of both agent-specific shocks and education level, as described in detail in the next subsection.

Savings are invested in a risk-free account with constant gross return  $R=2\%$ , an approach that is standard in the consumption-savings literature. Introducing a portfolio decision, as in Cocco, Gomes and Maenhout (2005), should not affect our conclusions for two reasons. First, we can always calibrate different levels for the rate of return on the portfolio to approximate the average return on any given portfolio. Second, as shown in Cocco et al. (2005), the portfolio allocations implied by this model are

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<sup>2</sup> For simplicity, we assume that the retirement age is exogenous and deterministic as in Gourinchas and Parker (2002), Carroll (1997) or Hubbard, Skinner and Zeldes (1995). We set the retirement age at 66 because we assume our stylized agent was born in 1945, and 66 is the age when people born in 1945 can retire and receive the full amount of social security benefit.

very similar across education groups, and thus would not significantly alter the returns to education.<sup>3</sup> The agent's wealth accumulation equation is given by:

$$(2) \quad W_{t+1} = R(W_t - C_t) + Y_{t+1}$$

where  $W_t$  denotes financial wealth at time  $t$ .

We assume that the agents cannot borrow against their future labor income or retirement wealth, so:  $W_{t+1} \geq 0$ , for all  $t$ . This constraint is standard in this class of models, and can be motivated using the standard moral hazard and adverse selection arguments.<sup>4</sup> We solve the maximization problem numerically using standard backward induction methods.<sup>5</sup>

### C. Labor Income Process

The income process follows closely the one originally proposed by MaCurdy (1982) and Abowd and Card (1999), and used in the life-cycle consumption and savings literature (e.g., Carroll and Samwick 1997, Cocco, Gomes and Maenhout 2005, Gourinchas and Parker 2002). Before retirement, the logarithm of labor income is the sum of deterministic components that can be calibrated to capture the hump shape of life cycle earnings as well as two random components, one transitory and one permanent. More precisely, agent  $i$ 's labor income at time  $t$  is given by:

$$(3) \quad \log(Y_{i,t}) = f(t, e_i, Z_{i,t}) + v_{i,t} + \varepsilon_{i,t}, \text{ for } t \leq K$$

where  $f(t, e_i, Z_{i,t})$  is a function of age ( $t$ ), the individual's education level ( $e_i$ ), and other individual characteristics ( $Z_{i,t}$ ),  $\varepsilon_{i,t}$  is an idiosyncratic temporary shock with a distribution of  $N(0, \sigma_\varepsilon^2(e_i))$ ,

$N(0, \sigma_{\varepsilon,i}^2)$ , where  $\sigma_{\varepsilon,i}^2 = \sigma_\varepsilon^2(e_i)$  is a function of education level ( $e_i$ ), and  $v_{i,t}$  is defined as:

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<sup>3</sup> There are differences in stock market participation rates across different education groups, but we could also capture these by considering different rates of return in our analysis, without actually having to endogenize the participation decisions (as in Gomes and Michaelides 2005, for example).

<sup>4</sup> Cocco, Gomes and Maenhout (2005) and Davis, Kubler and Willen (2006) consider versions of this model that allow for some level of uncollateralized borrowing.

<sup>5</sup> We optimize using grid search, discretize the state-space for the continuous state variable (cash-on-hand), interpolate the value function using a cubic spline algorithm, and compute expectations using Gaussian quadrature. More details are available upon request.



$$(4) \quad v_{i,t} = v_{i,t-1} + u_{i,t}$$

in which  $u_{i,t}$  is uncorrelated with  $\varepsilon_{i,t}$  and distributed as  $N(0, \sigma_{u,i}^2)$ , where  $\sigma_{u,i}^2 = \sigma_u^2(e_i)$ .<sup>6</sup> So the volatilities of the different income shocks are also a function of the individual's education level.<sup>7</sup>

Each year agents have a probability of suffering an unemployed spell ( $\pi$ ), in which case they will receive unemployment insurance for the duration of the spell. For tractability, we model income in a year in which an unemployment spell occurs as a fixed fraction ( $\theta$ ) of the worker's current income. Both the probability and this fraction are allowed to vary with the level of education, but they are otherwise identical across households:  $\pi_i = \pi(e_i)$  and  $\theta_i = \theta(e_i)$ .

Finally, retirement income is modeled as a constant fraction  $\lambda(e_i)$  of permanent labor income in the last working year, where  $\lambda(e_i)$  is allowed to vary by the level of education. Thus:

$$(5) \quad \log(Y_{i,t}) = \log(\lambda(e_i)) + f(K, Z_{i,K}) + v_{i,K}, \text{ for } t > K$$

This specification significantly facilitates the solution of the model, since it does not require the introduction of additional state variables.

#### *D. Selection and Unobserved Heterogeneity*

Before proceeding, it is important to acknowledge the implicit simplifying assumptions in our estimation approach, both with respect to the level of average earnings, and the dispersion of earnings, by education level. With regard to the level of earnings, the standard concern with using OLS to estimate the effect of education on earnings is that it might be biased. For example, ability may be correlated with education choice, leading to an upward bias if those with higher abilities are more likely to spend more time in school and also have higher earnings. Of course, it might also be biased downward if those with higher abilities are more likely to enter the labor force early and gain additional experience. A very large

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<sup>6</sup> Other studies have estimated a general first-order autoregressive process for  $v_i$  and found the autocorrelation coefficient very close to, and often undistinguishable, from one (Güvenen 2009, Hubbard, Skinner and Zeldes 1995).

<sup>7</sup> Huggett, Ventura, and Yaron (2006) show that these volatilities are also age dependent. We abstract from this in our analysis because the estimation of such age-variation would be too noisy in most of our sub-samples.

literature has examined these biases, using IV estimation methods, sample selection models and natural experiments to isolate the causal effect of education on earnings. In his excellent survey of the literature, Card (1999) concludes that most IV estimates (using either interventions in the school system or family background as instruments) are slightly higher than standard OLS counterparts but that the difference is often quite small (with the noticeable exception of Staiger and Stock 1997), suggesting that the (upward) ability bias in the OLS estimates may be offset by other factors inducing downward bias, such as the one mentioned above and measurement error in education. Because the aim of this paper is to show the effect of incorporating a given age-earnings profile by education into a life cycle framework, rather than trying to improve upon the vast literature on identification of causal effects, we simply estimate our earnings profile by regressing earnings on age dummy variables conditional on education and family structure.<sup>8</sup> To the extent that individual heterogeneity may bias the age-earnings profile, we include individual fixed-effect in our model as well. Our implicit assumption is that, consistent with the empirical findings of Card (1999), the net bias of OLS is small. Of course, our general methodology could be applied to any other estimates of age-earnings profiles by education.

With regard to the variance of earnings, the realized dispersion in observed earnings results both from unexpected income shocks and from unobserved heterogeneity across workers. Chen (2008), Cunha and Heckman (2007) and Cunha, Heckman and Navarro (2005) decompose this cross-sectional heterogeneity in income into these two components. From a different perspective, another source of heterogeneity comes from the observation that some people may be more able to self-insure certain types of income shocks through, say, transfers within household members or smoothing consumptions over time (Blundell, Pistaferri and Preston 2008). In the context of models with an endogenous education decision, such distinction between unexpected (or uninsurable) income shocks and individual heterogeneity is important. Because the heterogeneity is known to the agent, only the income shocks represent risk. For our purposes, we would ideally capture only the risk, and not the unobserved

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<sup>8</sup> This is equivalent to estimating an OLS model with the interactions between education and age on the right-hand side. Because we are interested in calculating life cycle earnings profiles and shocks across different population sub-groups and over time, the combination of IV and small samples would not allow for an efficient estimation.

heterogeneity component, and combining both would upward bias our measure of income risk. However, there is also an important selection issue that biases our estimate down: because unobserved heterogeneity affects the agents' education choice, the realized cross-sectional dispersion of income is effectively a truncated distribution, which means that observed wage inequality *understates* the potential wage inequality for a given level of education.<sup>9</sup> In this paper we take a conservative approach and estimate the income process including individual-specific fixed effects. In doing so we are effectively classifying all heterogeneity in individual average incomes as driven purely by ability, and none of it by risk/luck. On the other hand our estimates leave out potential age-variation in ability, and thus classifying that as risk, but when we consider both effects we are likely to be under-estimating our estimates of risk. In any case, later on we will still report results where we scale down the estimated variances to further control for any potential bias.

### III. DATA

#### *A. Sample Construction and Exclusions*

We use the Panel Study of Income Dynamics (PSID), a longitudinal survey of representative U.S. individuals and their families. When it started in 1968, the PSID had two independent samples: a cross-sectional national sample and a national sample of low-income families. We use the core cross-sectional sample of 2,930 households, which was drawn by the Survey Research Center (SRC) and was an equal probability sample of U.S. families in contiguous 48 states.<sup>10</sup> The second sample (known as the Survey of Economic Opportunity sample), which we exclude from our analysis, was an over-sample of low-income families. Between 1968 and 1996, the PSID annually interviewed individuals from the households in the

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<sup>9</sup> Chen (2008) explores these biases in a setting with an income process relatively similar to ours and finds that the two effects come very close to cancelling each other: after adjusting for both factors, the final estimate is within five percent of the unadjusted observed wage inequality.

<sup>10</sup> It is worth mentioning that, while the PSID started out as nationally representative, the manner in which they have followed people over time has led to a sample that is no longer fully representative (for example, it under-weights recent immigrants).

core sample. Household splits and merges were tracked; adults were observed as they aged, and children were followed as they grew into adulthood and formed their own family units. Since 1997, the PSID interviews have been bi-annual, and the most recent wave available at the time we began this analysis was conducted in 2011.

Only PSID household heads who are still in the labor force (self-reported as “working now”, “temporary laid off”, or “unemployed and looking for job”) and aged between 20 (or 22)<sup>11</sup> and 65 are included in the analysis of labor income process. We include both genders in our baseline estimates, and later we will separate the two samples and present results for each. We only include individuals who have an “exact” level of education: no high school, high school graduates, and college graduates. Those with some college education (but no college degree) or some post-secondary education are not used in our analysis, in order to obtain homogeneous education groups. Individuals who are younger than age 20 (22 if college graduate) are excluded. In the final sample, we have 7,985 agents and 73,001 annual earnings records. Descriptive statistics of individual characteristics and labor income of household heads aged between 20 (22 if college graduates) and 65 are shown in Table I.

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### *B. Definition of Education Levels*

We obtain completed years of education from the PSID individual data. In the years for which this is not available or missing, we use the information from the most recent wave. We then split the sample according to the level of education into five mutually exclusive categories based on years of schooling information: high school dropouts (less than 12 years), high school graduates (12 years), some college (more than 12 but less than 16 years), college graduates (16 years), and post-secondary degrees (more than 16 years). In order to obtain homogenous education groups, only people who have “exact”

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<sup>11</sup> We include earnings at age 20 and 21 for high school dropouts and high school graduates to maximize the efficiency of the labor income calibration, but we start at age 22 for college graduates. For all education groups, we use only earnings from 22 through 65 in our life-cycle, utility-based model of education value, as previously discussed.

states in education are included, so we exclude people who had some but did not finish college, as well as those who spent any amount of time in school beyond college graduation. This is important because drop-out rates among college graduates, in particular, are very high: according to data from the National Center for Education Statistics 36.8% (35.2%) of people enrolled in college in 1989-1990 (1995-1996) did not graduate and are no longer enrolled in the program after six years. These drop-out rates may imply non-trivial differences between the expected returns to education from enrolling in college and the expected returns to education conditional on actually obtaining a college degree (see, for example, Athreya and Eberly 2011, Ionescu 2011, Restuccia and Urrutia 2004). In our analysis we focus on the latter, so we use clean measures of completed education.

We estimate the earning equations separately for each of the three education groups: high school dropouts, high school graduates, and college graduates. Modeling income process with individual fixed effect is potentially problematic if education changes endogenously over the life cycle. However, since we only use individuals older than 20 (or 22 if the agent is a college graduate), there is not much variation in the level of education within each individual. In the small number of cases where an individual spent enough years in school and moved to a higher level defined-above, we consider the individual as a new entity once the level of education is changed.

### *C. Definition of Income*

Three sources of income are used in our analysis: labor income, unemployment income, and Social Security benefits. All the income figures are converted to 2010 U.S. Dollars using CPI-W.

Annual labor income is obtained through the household questionnaires in all years. Because the income is subject to progressive income taxation, thus lowering the net-of-tax returns to education, we perform our analysis based on post-tax labor income. For purposes of applying taxes, we effectively create a synthetic cohort from our observations. Specifically, we calculate the mean earnings at each age, regardless of the actual year of earnings. We then assume that our stylized agent turns 66 and retires on the first day of 2011, and then apply prior year income tax schedules based on age. For example, we

apply the 2010 federal income tax schedule to age 65 earnings, the 2009 schedule to age 64 earnings, and so forth, back to age 20.<sup>12</sup> We assume our stylized agents file individual (rather than married) tax returns and do not have any additional sources of earnings other than labor income, unemployment compensation, and Social Security benefits. We hence ignore earnings made by other household members. We apply only the federal income tax schedule and do not consider state income taxes. For simplicity, only labor income is subject to taxes: unemployment and Social Security benefits are assumed to be exempt from the income tax in our model.<sup>13</sup> Finally, because we include Social Security benefits in our analysis, we also include employees' portion of the FICA payroll tax that is dedicated to Social Security. (The labor earnings we observe in the PSID are already net of the employer portion.) We do not include the taxes or benefits associated with Medicare due to the difficulty of valuing the future benefits by income group (see, for example, Bhattacharya and Lakdawalla 2006). Similar to the way we apply the federal income tax, we also apply the Social Security payroll tax rate based on the age when the earnings are made, assuming that they retire at age 66. In the remainder of the paper, we use post-tax earnings unless otherwise specified, and the term "post-tax" is omitted to simplify exposition.

Annual unemployment income is also available in 1968-1992, 2005, 2007, 2009, and 2011 waves of PSID household questionnaires.<sup>14</sup> For the remaining period (1993 to 2003), the PSID provides two pieces of information on unemployment insurance income: the amount and the unit of time (weekly, bi-

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<sup>12</sup> In order to do so, we have to deflate the earnings to the nominal earnings of the year that the income tax is used. The after-tax earnings are then adjusted to 2010 dollars.

<sup>13</sup> According to the current tax schedule, the first \$2,400 of unemployment benefit and first \$25,000 of social security benefits are exempted from the federal income tax. Only 1.5% of the observations in the PSID have unemployment income larger than \$2,400, and the taxable part of unemployment benefit among these people is on average \$2,000. This implies this 1.5% of the sample would see their annual after-tax earnings decrease by \$200 or \$300 if unemployment earnings become taxable in our framework. This is at most 1% of the consumption certainty equivalent. Also, our estimates of Social Security benefits based on the benefit calculator suggest that high school dropouts and high school graduates have average annual Social Security benefits lower than the \$25,000 threshold. College graduates do have social security benefits higher than \$25,000, but including tax would only decrease the replacement rate by around 0.2%. Assuming all of unemployment and Social Security benefits are not taxable would therefore have only a trivial effect on our numerical results and does not change our main arguments and findings.

<sup>14</sup> Between 1968 and 1976, unemployment income is reported in brackets rather than actual numbers. In these years, the median of each closed bracket is used as an individual's unemployment income. For the top bracket (\$10,000 or above), we code the unemployment income as if it's top-coded at \$10,000. Very few respondents fall into this top bracket—\$10,000 in 1976 corresponds to roughly \$40,000 in 2010 dollars.

weekly, or annually). Along with weeks of unemployment, we can calculate the amount of unemployment income that an individual received each year, assuming that unemployed workers receive unemployment compensation during the whole spell of unemployment. This probably overestimates unemployment income because benefits are typically available for only 26 weeks after the initial claim.<sup>15</sup> As a quick robustness check, we examined whether there is a discontinuity in the amount of unemployment benefits received around 1993, and found no evidence of a spike in the pattern of mean individual unemployment income when the measure changed.

Measuring Social Security income is more complicated. The amount of Social Security benefits at the individual level are only available in limited waves (1986-1993, 2005, 2007, 2009, 2011) of the PSID. In earlier waves, the PSID only asks for these benefits at the household level, and therefore includes spousal benefits as well as other family benefits, such as those paid to any minor children in the household. Because it is impossible to recover Social Security benefits at the individual level, we feed the pre-tax age-earnings profile into the Social Security benefit calculator provided by the Social Security Administration to calculate individual level benefits, assuming the stylized agent turns 66 on January 1<sup>st</sup>, 2011 and starts to receive benefits on that day. To calculate the average Social Security replacement rate for each education group, we take twelve times the amount of the monthly Social Security benefit (which is equal to the Social Security “Primary Insurance Amount” for those retiring at the Normal Retirement Age), and divide it by mean annual earnings. We assume the replacement rate is the same for all agents who have the same level of education. As a check on our methodology, calculating Social Security benefits in this manner gives numbers very close to those reported in the PSID if we evenly distribute the household level benefits reported in the PSID among potentially eligible household members (those who are older than 65).

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<sup>15</sup> The federal government may extend the eligibility during economic downturns. For example, during the recent recession, the federal government pays up to 73 weeks of unemployment benefits, bringing the total duration of unemployment insurance benefits up to 99 months.

#### *D. Mortality Rates*

The present value of the lifetime benefits of education will also depend on the distribution of possible life spans. We use cohort mortality rates from the U.S. Social Security Administration. We use the 1945 birth cohort table because we assume our stylized agents were born in 1945 and turn 66 in the beginning of 2011. We use these mortality rates to calculate the cumulative survival probabilities in equation (1) above. It is well-known that education is negatively correlated with mortality rates (i.e., more highly educated individuals live longer). We do not incorporate this into our calculations, however, because the survival probabilities enter the lifetime utility function in equation (1), and the calculation and comparison of certainty equivalents is not well-defined when the utility function itself differs across the two states being compared. To the extent that education has a positive causal effect on life expectancies, this would cause our estimates to understate the gains from education.

### **IV. ESTIMATING THE INCOME PROCESS**

#### *A. Labor Income Profile and Shocks*

We first estimate the labor income process (equation [3]), by regressing the logarithm of income on age dummies, individual fixed effects, and a set of other control variables. As is standard in the literature, for purposes of solving the numerical model, we will capture the age component of the income process as a third-order polynomial of age. Therefore, after estimating this process, we regress the age dummies coefficients from the estimated income process on a set of age polynomials. Figure I shows the fit of the third-order age polynomials over life cycle labor income profile.

--- Insert Figure I about Here ---



### B. Variance Decomposition

After obtaining the residuals from equation (3), we now decompose the income variation into a permanent and a transitory component.<sup>16</sup> As previously discussed, we assume that the permanent component follows a random-walk process, and we apply the methodology proposed in Carroll and Samwick (1997) to estimate the variances of the two shocks. If we define  $r_{i,d}$  as

$$(6) \quad r_{i,d} \equiv \log(Y_{i,t+d}^*) - \log(Y_{i,t}^*), \quad d \in \{1, 2, \dots, 43\}$$

where  $Y_t^*$  is given by

$$(7) \quad \log(Y_{i,t}^*) \equiv \log(Y_{i,t}) - \hat{f}(t, Z_{i,t})$$

it follows that

$$(8) \quad \text{Var}(r_{i,d}) = d \times \sigma_u^2 + 2\sigma_\varepsilon^2$$

We can thus estimate  $\sigma_u^2$  and  $\sigma_\varepsilon^2$  with any two difference series of  $r_{i,d}$  by running an OLS regression of  $\text{Var}(r_{i,d})$  on  $d$  and a constant term (for all  $d$ ). By doing so, we constrain the estimates of  $\sigma_u^2$  and  $\sigma_\varepsilon^2$  to be the same across all individuals. In our estimates, we include all possible series of  $r_{i,d}$  to maximize efficiency. We also apply winsorization on  $r_{i,d}$  and replace extreme values (below 1<sup>st</sup> percentile or above 99<sup>th</sup> percentile) with the values of 1<sup>st</sup> percentile and 99<sup>th</sup> percentile, respectively. Our results of variance decomposition are shown in Table II. We first use annual labor income of those who are fully employed in a given year (that is, hour of unemployment is zero) only, and then use labor plus unemployment income and also include those who have experienced unemployment.

--- Insert Table II about Here ---

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<sup>16</sup> In section II.D we discussed the potential impact of biases due to unobserved heterogeneity and sample selection, and evidence suggesting that they probably have a very small impact on our estimates.

Comparing across education groups we find a decreasing pattern for transitory shocks, and a u-shape for permanent shocks. The null hypotheses that transitory shocks are the same and permanent shocks are the same across education groups are both rejected. These results suggest that less-educated workers face more year-on-year income risk, while college graduates have significantly higher career heterogeneity. Previous studies have found mixed results on this dimension. For example, Low, Meghir, and Pistaferri (2010) used both the SIPP and PSID, and estimate higher volatility of both permanent and transitory shocks for those with higher education level. However, they only consider two different education groups (“high school or less” versus “at least some college”), which might explain the differences in the case of the permanent shocks. Hubbard, Skinner, and Zeldes (1994) used a limited time period –the 1983-1987 PSID sample –and the same definition of levels of education as in our study, and find a decreasing pattern for both types of shocks. Carroll and Samwick (1997) consider the 1981-1987 PSID sample and obtain a decreasing pattern for permanent shocks and a u-shape for transitory shocks, across five different education groups.<sup>17,18</sup>

Although the magnitudes of the volatilities for the permanent component (Table II) are slightly lower than those reported in previous studies (Carroll and Samwick 1997, Guvenen 2009, Hubbard, Skinner and Zeldes 1994, Low, Meghir and Pistaferri 2010), our estimates of transitory volatility are higher than those most commonly found in the consumption and savings literature. For example, Carroll and Samwick (1997) estimate standard deviations of transitory shocks between 0.185 and 0.257, while Hubbard, Skinner, and Zeldes (1994) estimate values between 0.118 and 0.200. Four main factors contribute to our higher estimates. First, as discussed above we consider after-tax income, and while this decreases the volatility of the permanent component of income, it increases the volatility of its transitory component because tax rate changes become an additional source of (transitory) shocks. Second, the

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<sup>17</sup> The five groups are: some high school, high school degrees, some college, college degrees, and post-secondary degrees.

<sup>18</sup> Other studies either do not provide the same decomposition of shocks or do not report comparable numbers, but overall the results are again mixed. Some found college graduates have the smallest wage variations (see, for example, Cameron and Tracy 1998, Dynan, Elmendorf and Sichel 2012, Heckman, Lochner and Todd 2006, Jensen and Shore 2008), while others found higher educated group actually have larger wage variations (see, for example, Cunha and Heckman 2007, Moffitt and Gottschalk 2012).

other two studies exclude income outliers while we prefer instead to winsorize the data.<sup>19</sup> Third, they estimate their profiles at the household-income level, while we use individual income data because we want to measure the returns to education for a given individual. Naturally, when measured at the household level, income volatility decreases due to the smoothing across household members. Our choice of individual income data also follows standard practice in the labor economics literature (see, for example, most of the papers cited in the previous paragraph). Finally, we consider a different time period and, as we will show below (when we present Table VII), these variances have increased over time, consistent with the results in Cunha and Heckman (2007), Gottschalk and Moffitt (1994), and Moffitt and Gottschalk (2012).

Estimates of the volatility of transitory shocks can be upward biased due to measurement error, and for this reason some authors prefer to “scale down” the estimated values. Gourinchas and Parker (2002) argue for this type of adjustments to correct for measurement error and potential upward estimation bias due to mis-specification of the earnings process. Bound and Krueger (1991) study measurement error in wages reported in the Current Population Survey and conclude that 20% to 35% of the variance is indeed due to mis-measurement. Hubbard, Skinner and Zeldes (1995) assume that the transitory shocks are purely measurement error and exclude them completely from their analysis. Given the possibility that these are over-stated, we will report two alternative scenarios for the volatility parameters: one with the estimated parameters values and one where we have scaled down our estimates by 25% (i.e., multiplying them by  $\frac{3}{4}$ ).

### *C. Probability of Unemployment, and Income in Unemployment-Spell Year*

Our estimate of the income process for the employed is based on the sample those who have positive labor income and zero hours of unemployment in that year. We then estimate separately the income of those who were unemployed for some period during the year, and the probability of such event

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<sup>19</sup> For example, Carroll and Samwick (1997) exclude households whose income in any year is less than 20% of average over sample period, while Hubbard, Skinner, and Zeldes (1994) exclude households with annual income less than \$3,000. Including these exclusion criteria would eliminate several unemployed individuals from our sample, and we want to capture this dimension of income risk as well.

occurring within our sample. In the U.S., an unemployed individual can typically receive the unemployment insurance for up to 26 weeks, and the mean replacement rate of weekly unemployment benefits is around 45% of pre-displacement weekly earnings (McCall 1996). However, the average duration of unemployment is substantially less than this: the mean unemployment spell in the U.S. is 9 weeks (McCall 1996, Meyer 1990). It is hence not plausible to assume an agent is either fully-employed or fully-unemployed in an entire year when we attempt to account unemployment risk in our model. To address this, we define “unemployment rate” in a year as the proportion of individuals who ever experience any unemployment in that given year, regardless of the length of unemployment spell. The “unemployment earnings” of these individuals are then defined as their unemployment benefits when they are not working plus the labor earnings when they are working. In other words, the “unemployment earnings” in our framework is the expected annual income from unemployment benefits and labor earnings among those who experience any unemployment spells in a year. Similarly, the replacement rate of unemployment earnings is calculated as the ratio of annual income, including labor earnings and unemployment benefits if applicable, between those who experience unemployment and those who do not experience unemployment in a given year.

Table III tabulates the probability of experiencing an unemployment spell within a year in our sample, across the different education groups ( $\pi(e_i)$ ). Similarly, for the different education groups, we also report the average yearly income for the two separate samples (those with and without an unemployment spell) which we then use to compute the replacement rate of income during an unemployment state within our model ( $\theta(e_i)$ ). The averages are computed using the PSID sample weights.

--- Insert Table III about Here ---

As expected, the probability of unemployment decreases significantly with education, as did the volatilities of transitory income shocks above. This confirms that short-term income risk is more severe for workers with less education. In particular, college graduates have a much lower probability of being

unemployed than the other two groups (7.38% versus 14.38% for high school graduates, and 20.24% for those with no high school). Of course, higher income individuals lose a higher fraction of their income when unemployed (with a replacement rate of 52.06% versus 70.17% for high school graduates and 78.91% for those with no high school), owing in large part to the fact that unemployment benefits are capped.

#### *D. Retirement Income*

For those aged 65+, only Social Security benefits are counted as income. Consequently, we are excluding records of people who work beyond age 65 or retire before 65. This is done both for both practical and conceptual reasons: practically, it substantially simplifies the computational process; conceptually, it allows us to abstract away from individual decisions about whether to consume part of potential income in the form of earlier retirement. We compute the retirement income replacement ratios as described in section III.C. As noted above, the benefits and replacement ratios calculated based on the SSA benefit calculator are very similar to the PSID household numbers after adjusting for the number of individuals over age 65 in the household. As expected given the design of the non-linearity of the Social Security benefit formula, the average Social Security benefits increase with the education level (\$1,481, \$1,794 and \$2,264, respectively for the different groups), while the replacement ratios of average lifetime earnings decrease (60.05%, 57.88% and 45.16%, respectively for the different groups).

### **V. BASELINE RESULTS: AVERAGE GAINS IN THE SAMPLE**

By solving the model for a given income process (and hence a given level of education), we can compute the lifetime expected utility of the agent conditional on education. Following the convention in the literature, we express lifetime utility as a certainty equivalent level of consumption. In addition, we convert these certainty equivalents into wealth levels, since those provide risk-adjusted present values of human capital, and can thus be compared with direct measures of the costs of education.

### *A. Gains from Education: Expected Lifetime Earnings*

In this section, we start by calculating the gains from education by comparing average outcomes conditional on education, without incorporating of the utility consequences of unemployment and income risk. These results will allow us to disentangle the different components of the returns to education.

Relative to the bulk of the existing literature on the returns to education, even our baseline case has several important differences. First, we are computing lifetime present values as opposed to wage differentials conditional on age. Second, we incorporate income and payroll taxes, mortality rates and Social Security benefits. To understand the impact of these different elements, we start with pre-tax earnings in the first two panels of table IV. Those are the only two cases in paper in which the gains from education are expressed in pre-tax terms.

--- Insert Table IV about Here ---

In the first panel of Table IV, we show the gains from education simply as the undiscounted summation of mean pre-tax inflation-adjusted labor earnings between 22 and 65 multiplied by the conditional survival probabilities at each age, by different education groups. In the second panel we repeat this calculation using a 1% real annual discount rate. We set the discount rate for this calculation to 1% because our baseline discount factor in the utility-based model is 0.99, thus allowing for an easier comparison of results between the two approaches. The percentage gains are almost identical in the two cases, so we can focus on Panel B. The net-present value of a high school degree is \$1,502,833, corresponding to a gain of \$335,138 (28.70%) relative to the no-high-school scenario, while the net-present value of a college degree is \$2,536,631, corresponding to a gain of \$1,033,798 (68.78%) relative to a high school degree. These simple present value calculations are very much in-line with estimates of the value of a college degree reported in the popular press.<sup>20</sup>

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<sup>20</sup> For example, <http://usgovinfo.about.com/od/moneymatters/a/edandearnings.htm> reports the results of Census Bureau estimates that a college degree is worth about \$1 million more over ages 25 to 65 than a high school degree.

In Panel C we repeat the calculations from Panel B, but using after-tax income. Naturally, all present values decrease and, due to the progressive nature of income taxation, it decreases more for those with higher education. Workers with a high school degree have average *after-tax* discounted lifetime earnings \$255,399 higher than those without high school diploma (a 26.39% increase), while individuals with college degrees have *after-tax* lifetime earnings which are \$734,528 higher than those of high school graduates (a 60.06% increase).

In Panel D we show how the gains from education change after we add unemployed agents to the sample. The gains from education here are calculated as the expected value of earnings, which are equal to the likelihood of employment times expected labor earnings plus the likelihood of unemployment multiplied by the level of unemployment benefits (discounted and adjusted for mortality as in the previous panels). The comparison between Panels C and D confirms that considering the likelihood of unemployment will increase the value of education due to the higher probability of unemployment for less educated people. The gains from high school education increase to 27.39% and the gains from college increase to 60.51%.<sup>21</sup> The effect here is not very large because, as shown in Table III, the reduction in income during unemployment is more severe for those with higher education. However, it is important to recall that this calculation ignores risk preferences (we are only computing expected values) and, as shown later on, the impact of income risk is much larger when we take into account for individuals' risk aversion.

In the final panel (E) we include Social Security income, i.e., income received during the retirement period. Naturally all present values increase and, as a result, the dollar gains are also higher. The percentage gains, however, are lower, reflecting the non-linear Social Security benefit structure that provides higher replacement rates for individuals with lower lifetime earnings. This is particularly noticeable for college graduates, for whom the percentage gain decreases from 60.51% to 56.11%.

Overall, these numbers are lower than those mentioned in conventional estimates of the value of college education, especially those reported in the popular press, which often range from \$800,000 and

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<sup>21</sup> The dollar gains are slightly smaller since the net-present values are naturally lower for all.

\$1,000,000.<sup>22</sup> This is due to the inclusion of taxes, Social Security benefits, unemployment probabilities, mortality adjustments and time-discounting. The results in Panel B, which only adjust for discounting and mortality risk, are actually very similar to conventional estimates, suggesting the importance of the other factors. By comparing the results in the different panels, we can see that the largest difference in levels and percentage gains comes from the inclusion of income taxes. Next, we turn to a discussion of how these results change when one takes into account risk preferences in a utility-based model.

### *B. Gains from Education: A Baseline Case*

We now compute the returns to education from our utility-based calculations. In our baseline case, we assume that all agents have a relative risk aversion coefficient ( $\gamma$ ) of 2 and a discount factor ( $\beta$ ) of 0.99. We report both the certainty-equivalent consumption levels (standard calculation within a utility-based model) and the corresponding certainty equivalent initial wealth levels, the latter of which are more directly comparable to the results in Table IV. These measures can be compared to the cost of education and with the typical estimates in the returns to education literature. The results are shown in Table V.

--- Insert Table V about Here ---

In Panel A we first report the results without unemployment risk and without income shocks, to facilitate the transition from Table IV. In other words, these calculations assume that all agents within a given education group will receive the average income within that group, just like the ones in the previous table. Comparing the results we find much lower certainty equivalent gains for both levels of education. For high school (college) the improvement in the present value of after-tax lifetime average earnings is now \$223K (\$719K) versus \$283K (\$759K) in Panel E of Table IV, corresponding to percentage gains of 17.02% (46.73%) versus 26.52% (56.11%) in the previous calculations. Since risk-preferences are still irrelevant in this calculation, the differences in the results are coming exclusively from life-cycle aspects.

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<sup>22</sup> As another example, see a Wall Street Journal article on February 2, 2010 by Mary Pilon (<http://online.wsj.com/article/SB10001424052748703822404575019082819966538.html>).



In particular, with upward sloping age-income profiles, agents are liquidity constrained early in life, and therefore the marginal utility of current consumption is high. As one approaches retirement, we observe the opposite. As a result, conditional on the *level* of average lifetime income, steeper income profiles, such as the one for college graduates, are not as highly valued in utility terms as they are in a simple present value calculation.

In Panel B we report results from the lifecycle model that include all sources of income shocks. We find that the typical high school graduate will enjoy a 30% higher level of consumption, per year, than those who did not attend high school at all. When expressed in terms of lifetime certainty equivalent (i.e. risk-adjusted) wealth, this corresponds to an increase of \$238K. The risk-adjusted present-discounted value of the human capital of an agent without any high school education is \$792K, while for a high school graduate that number rises to roughly \$1 million. In other words, an individual with relative risk aversion of 2, and discount factor of 0.99 should be willing to pay as much as \$238K to attend and complete high school.

The net gains from college education are again larger. The (risk-adjusted) present value of human capital of the average college graduate is almost \$1.5 million dollars, and \$441K higher than the human capital of an otherwise identical high school graduate. This corresponds to a 42.79% increase in annual certainty-equivalent consumption. The net benefit is far lower than the “million dollar” figures often cited in the popular press.

By comparing the results in Panels A and B, we see that while the gains from high school increase when we take into account earnings heterogeneity and risk preferences (from 17.02% to 30.14%), the gains from college actually decrease slightly (from 46.73% to 42.79%).<sup>23</sup> These results can be understood from the estimations results reported in Tables II and III. Relative to workers without high school education, high school graduates have much lower income volatilities (for both permanent and

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<sup>23</sup> If we compare dollar gains, the certainty equivalent wealth increase for high school graduates only increases slightly (from \$223K to \$238K). But certainty equivalents are naturally much smaller once we account for uncertainty. Therefore a given percentage gain would now correspond to a lower dollar value benefit. For the same reason, the small reduction in the percentage wealth certainty equivalent gain from college actually corresponds to a very large decrease in the dollar gain (from \$719K to \$441K).

transitory shocks) and a much lower probability of suffering an unemployment spell (with a very similar replacement ratio). Therefore, a high school degree also decreases lifetime earnings variability thus increasing its value even further once we take into account for risk aversion. On the other hand, relative to high school graduates, college graduates face a much more skewed earnings distribution with much higher career heterogeneity (higher volatility of permanent earnings shocks). This is partially attenuated by the fact that they are less subject to temporary shocks (lower volatility of transitory earnings shocks and a much lower probability of unemployment), but the overall earnings distribution is more uncertain, and, therefore, the corresponding percentage certainty equivalent gain is slightly lower when we account for risk aversion.

Finally, as previously discussed, the estimates of the volatility of earnings shocks are potentially subject to measurement error and/or inflated due to unobserved individual-level heterogeneity. To take this into account, in Panel C we repeat our calculations under alternative volatility measures (we decrease our estimated numbers by multiplying by a factor of  $\frac{3}{4}$ ). The results are very similar and therefore we conclude that these potential concerns do not seem to have a significant impact on our calculations. Consequently, for the remainder of the paper, we only report results for the first case.

### *C. Net Gains and Returns to Education*

In this section we compare the present value of education with the cost to obtain a measure of the return to the investment in education. This calculation is subject to some important caveats, discussed below, which is why in the paper we focus mostly on the present value calculations only. Nevertheless we feel that these are also useful numbers to report.

There are two sources of costs to education: the direct costs and the opportunity cost in terms of foregone wages. In the academic year of 2008-2009, average tuition and fees for a four-year public (private) college is \$6,585 (\$25,243) and the cost for room and board is \$7,707 (\$8,996) per year, for a four-year non-discounted total of \$57,168 (\$136,956).<sup>24</sup> Naturally the expected payoff in terms of the

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<sup>24</sup> [http://militaryfinance.umuc.edu/education/edu\\_college.html](http://militaryfinance.umuc.edu/education/edu_college.html)

present value of earnings is also likely to be much higher for those graduating from private colleges, than from those graduating from public ones. Unfortunately we cannot distinguish these in our data, so we will instead treat the private college and public college costs numbers as giving us a lower and an upper bound on the return, respectively.

We compute the opportunity cost by measuring the average expected after-tax income of high school graduates household heads in our sample, during the ages of 18, 19, 20 and 21, which corresponds to \$73,112. This represents an upper bound on the opportunity cost for two reasons. First we are considering the expected value wages without adjustment for risk. Second we exclude those household heads that are enrolled in college, even though some of them might be working part-time and thus already earning an income.

We can now combining these calculations with the previous gains since those are already discount present values. We find that the measured net benefit from college ranges from \$231K and \$311K. Therefore, even taking into account the direct costs and the forgone earnings from age 18-22, college education is a significant positive net present value investment.

#### *D. The Role of Preference Heterogeneity*

The previous results apply to an agent with a risk aversion coefficient of 2, and a discount factor of 0.99. In this section we now consider different alternative values for the preferences parameters, and explore how the gains from education might vary across different groups of the population, and in particular they might be affected by the agents' risk preferences.

In Panel A of Table VI we report the gains from high school education measured in (risk-adjusted) present value of lifetime human capital, both in dollar terms and in percentages.

--- Insert Table VI about Here ---

The gains from high school education increase as risk aversion increases. For example, moving from 2 to 4 increases the certainty equivalent gain by \$30-40K. As previously shown (Tables II and III), high school graduates have much lower income volatilities (for both permanent and transitory shocks) and much lower unemployment risk than those without high school education. Therefore, in addition to providing higher average income, a high school degree also decreases lifetime earnings variability which is particularly valuable for the more risk-averse agents. Overall we find that, for reasonable preference parameters, the welfare gains can vary from just over \$223K (risk aversion of 1 and discount factor of 0.99) to nearly \$273K (risk aversion of 4 and discount factor of 0.97). These numbers highlight the role of preference heterogeneity, and in particular risk preferences, when computing the certainty equivalents from education.

In Panel B of Table VI we report the returns to college education for different values of the preference parameters. These gains are also sensitive to risk preferences, but they decrease with risk aversion. For individuals with risk aversion of 1 the gains are almost \$590K, while for those with risk aversion of 4 they are around \$225K. Part of this difference is simply due to the fact that the dollar value of certainty equivalents naturally decreases with risk aversion, hence even for the same percentage gain, the dollar value improvement would be lower. However, we can see that, even in percentage terms, the gains are lower for the more risk-averse agents: close to 35% versus approximately 45%-50% for the less risk-averse agents.

To understand these results we again need to consider the empirical estimates in Tables II and III. Relative to high school graduates, college graduates are less subject to temporary shocks (lower volatility of transitory earnings shocks and a much lower probability of unemployment), but they have more career heterogeneity (higher volatility of permanent earnings shocks). In other words, although the average lifetime earnings are much higher than for high school graduates, the distribution is much more skewed. Therefore, the more risk-averse agents will place a lower value on this this distribution of potential income realizations than would agents with lower risk aversion coefficients. The significant heterogeneity in certainty equivalent gains highlights again the importance of taking into account for

heterogeneity in risk preferences when computing the gains from education. Moreover, if we compare these numbers with the ones reported in calculations in Table IV, we find that the gain for an agent with risk aversion of 4 is actually less than a third of the one computed by the simple baseline which implicitly assumes risk neutrality (\$225K-\$245K versus \$759K).

If we now repeat the calculations in section V.C, we find that the net gains from college investment, assuming the upper bound on the estimate of the cost, can vary from as low as \$16K (for the more risk-averse agents) to as high as \$379K (for the less risk-averse agents). In terms of returns, this corresponds to a range between 7.6% and 180%. The wide dispersion in these numbers reflects once again the importance of considering preference heterogeneity and risk-adjustments when measuring the benefits of education. If we instead consider the lower bound estimate of the cost we reach similar conclusions, as the net gains will vary from \$96K to \$459K, and the returns from 74% to 353%.

## **VI. GAINS FROM EDUCATION OVER TIME**

It is well-documented in labor economics literature that the education wage premia have increased over time (for example, Autor, Katz and Kearney 2008, Card 1999, Goldin and Katz 2007, Katz and Murphy 1992, Katz and Autor 1999, Lemieux 2006), particularly in the 1980s.<sup>25</sup> In addition, it has also been shown that earnings volatility has increased since 1980s (Cunha and Heckman 2007, Gottschalk and Moffitt 1994, Moffitt and Gottschalk 2012).

These findings have several possible implications for our study. Naturally, increases in baseline returns to college education will increase the certainty equivalents. However, if the simultaneous increase earnings variation is concentrated among the more educated workers, this may decrease the gains from education for risk-averse agents. We address these issues in this section.

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<sup>25</sup> Different explanations have been proposed and discussed, namely an increased demand for college graduates (Katz and Murphy 1992). Related to this, some authors argue in favor of a skill-biased technological change (Autor, Katz and Krueger 1998, Krueger 1993), which asserts that the technology development in 1980s and early 1990s was biased toward higher-educated people. Although this theory has been challenged by some recent studies (for example, Card and DiNardo 2002, Lemieux 2006), it also provides an explanation for the increase of wage inequality in the U.S. since 1980s (Autor, Katz and Kearney 2008).

### *A. Volatility Estimates for Different Time Periods*

In the following analysis, we repeat our calculations for three separate sample periods: 1969-1980, 1981-1990, and 1991-2011. Even though these three periods have different length (both in terms of time and waves of data), we consider these splits based on the previously-discussed evidence that returns to education, especially to college degrees, have increased over time, particularly during the 1980s. Our results also reflect the changes in the tax system: we assume stylized agents retire in the end of 1980, 1990, and 2010, respectively, for the three subsamples. And hence, in the 1969-1980 subsample, we apply 1980 payroll and federal income tax schedules to earnings at age 65, the 1979 tax schedule to earnings at age 64, and so forth.<sup>26</sup> Similarly, the 1990 tax schedule is applied to age 65 earnings in the 1981-1990 subsample, the 1989 tax schedule is applied to age 64 earnings, etc. We use the same tax scheme as what we used in previous two sections for the 1991-2011 subsample. The U.S. income tax has, in general, become less progressive over time. In Table VII we report the standard deviations of the different income components (transitory and permanent) for the three education groups in each subsample.

--- Insert Table VII about Here ---

Consistent with the above-mentioned previous findings in the literature, 5 out of the 6 standard deviations are higher in the 1980s than in the first part of the sample (with the other one difference being statistically insignificant). The estimates for permanent volatility are significantly higher for both college graduates (+4.8%) and those with no high school (+4.7%). For transitory shocks, there are large increases for high school graduates (+3.6%) but small and statistically insignificant changes for college graduates and those without high school degrees.

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<sup>26</sup> The payroll tax started in 1937, which is when our stylized agent in the 1968-1980 subsample turned 22. Hence, earnings at all ages used to calculate the consumption certainty equivalent are subject to payroll tax.

In the later part of the sample we observe large increases in the point estimate of transitory volatility for all groups: +8.6% for college graduates, +5.4% for high school graduates, and +14.8% for those without high school. With regards to the permanent shocks, we now find decreases for the two lowest education groups and a further increase for college graduates.

Overall, college graduates have experienced increases in both sources of earnings dispersion over time, i.e., both career heterogeneity and transitory earnings volatility are much higher in the later sample. High school graduates have experienced consistent increases in transitory volatility, but the impact of permanent shocks has remained relatively constant. Finally, those with no high school registered a very large increase in career uncertainty in the 1980s, followed by a decrease in the later part of the sample when transitory volatility almost doubled.

#### *B. Certainty Equivalent Gains for Different Time Periods*

As before, we start by reporting the simple average present-discounted value of lifetime earnings. This is shown in Table XI for the three different sub-periods. To reflect the change in longevity over time, we use the cohort mortality tables in 1915, 1925, 1945 for the 1969-1980 (age 66 in 1981), 1981-1990 (age 66 in 1991), and 1991-2011 (age 66 in 2011) subsamples, respectively. We also account for the changes in Social Security benefits schedule by feeding the age-earnings profile into the benefit calculator provided by the Social Security Administration assuming stylized agents retire in the end of 1980, 1990, and 2010. Interestingly, we observe noticeable reductions in the discounted lifetime earnings from both high school and no-high school in the 1980s (from \$1,454K to \$1,324K, and from \$1,118K to \$1,016K, respectively), followed by a small recovery for both groups (to \$1,333K and \$1,024K, respectively). For college graduates, the lifetime earnings increased modestly from 1968-80 to 1981-90 and then significantly in 1991-2011 (from \$2,035K to \$2,052K to \$2,165K).

--- Insert Table VIII about Here ---

As a result, the gains from college education have increased consistently over time, both in percentage terms (from 39.96% to 54.99% and then 62.30%) and in dollar value (from \$581K to \$728K and then \$831K). In percentage terms, the gains from high school remained largely constant over time.

In Table IX we now report the gains from education for the three sub-samples, under the utility-based calculations.

--- Insert Table IX about Here ---

For high school graduates, we again observe a moderate decrease in certainty-equivalent consumption over time relative to high school dropouts. As shown in Table VII, in the 1980s, the volatility of earnings increased both for high school graduates and for those without high school (particularly for transitory shocks for the former, and for permanent shocks for the latter). As a result, the change in gains from education is mostly driven by the change in the average expected value; therefore this result is very similar to the one in Table VIII.

The results for college graduates exhibit significant differences. Although the gains from college education increased over time in Table VIII, they decreased quite substantially over time in Table IX. That is, while the average present value of labor income for a college graduate has increased over this period, the dispersion of outcomes is now significantly larger, particularly when compared with the one for high school graduates. As Table VII shows, in the 1980-1990 period both groups had almost the same exact volatility of permanent shocks (13.3%), while in the 1991-2007 period this volatility has decreased for high school graduates (to 12.3%) but increased for college graduates (to 15.9%).

It is interesting that gains from education measured in expected lifetime earnings (Table VIII) and utility-based certainty equivalent consumption (Table IX) demonstrates opposite time trends. First, as mentioned above, the magnitude of gains from college education increased in Table VIII over time but decreased in Table IX. Second, in percentage terms, gains from college are always much higher than gains from high school if measured in expected lifetime earnings with the gap widening over time. The



trend is also opposite in the utility-based calculation—the gains from college education weren't much larger than the gains from high school completion in the early period, and the former actually became smaller than the former in later periods.

Such results again epitomize how earnings risks change the value of education. In a utility-based calculation, the higher expected lifetime earnings for college degree are offset by higher earnings variation, especially the permanent component. We show that higher earnings risks can significantly reduce the ex-ante gain from college completion in the recent period, even though the expected lifetime earnings remain high.

## **VII. GAINS FROM EDUCATION: GENDER DIFFERENCES**

In this section we study how the returns to education vary across genders. Here it is important to remember that in our analysis we only consider individuals that are classified as the head of household in the PSID. Therefore our sample of females is unlikely to be representative of the general female population and the results should be interpreted with that important caveat in mind.

We start by estimating the after-tax income process from the PSID for the male and female subsamples separately. In Table X we report the standard deviations of the different income components (transitory and permanent) for men and women separately.

--- Insert Table X about Here ---

Without exception, all 6 standard deviations are higher for women than for men, both for transitory and for permanent shocks. These differences are statistically significant and economically very large.

In Table XI we compute the average present-discounted value of lifetime earnings, i.e. the valuations under risk-neutrality, for both men and women separately. To account for the gender

difference in longevity, we compute the results in this section based on the mortality rates from male and female cohort tables of 1945, respectively.

--- Insert Table XI about Here ---

There are three main results. First the average present values are much smaller for women than for men, for all education categories. The average discounted after-tax lifetime earnings of a woman with a high school degree are \$978K versus \$1,450K for a man with the same level of education. Equally large differences apply for those without high school education (\$648K for women versus \$1,175K for men) and for those with a college degree (\$1,392K for women versus \$2,232K for men).

Second, the improvement in average discounted after-tax lifetime earnings for high school graduates is much higher for women than for men, \$330K versus \$274K, which, given the much lower base earnings for women (discussed above), maps into a percentage gain of 50.92% versus 23.38%, respectively. Third, this result is reversed for college graduates. While women with a college degree enjoy an increase in discounted after-tax lifetime earnings of \$413K, the equivalent number for men is \$782K. In percentage terms the difference is “smaller” due again to the lower base for women, but the result remains: 42.25% versus 53.92% respectively.

In Table XII we now report the gains from education for the men and women sub-samples separately, under the utility-based calculations.

--- Insert Table XII about Here ---

The certainty equivalents for each level of education are much lower for women than for men. This comes naturally from the results in both Table XI, where we found the same pattern for the average present-discounted values, and Table X, which showed that the earnings distribution for women exhibits much higher volatility than the male counterpart. The results in Table VII also suggested that the gains

from education should increase much more for women than for men in the utility-based calculations, because they benefit from much more significant reductions in earnings volatility. Indeed this is what we find. The percentage certainty equivalent gain from high school is dramatically higher for women than for men (87.98% versus 22.45% respectively). A similar effect is present in the welfare gains from college degree where we now observe a higher percentage gain for women than for men (54.82% versus 39.01%, respectively) even though Table XI documented lower average lifetime earnings increases for women (38.53% versus 50.10%, respectively). These results once again reinforce the importance of the utility-based calculations.

### **VIII. DISCUSSION AND CONCLUSION**

Using a utility-based model that is standard in the life-cycle consumption and saving decisions analysis, we show that accounting for earnings risks and individual risk preference significantly changes the relative values of three different education levels—no high school, high school degree, and college degree. A high school degree confers not only higher expected lifetime earnings, but also reduced earnings volatility and lower risk of unemployment. College graduates on average have much higher expected lifetime earnings compared to high school graduates, but because they also face higher earnings volatility our results suggest the value of college degree declines with risk aversion. Accounting for progressive income taxation, unemployment insurance, and Social Security taxes and benefits further reduce the value of education. Overall, we conclude that the value of a college (high school) degree to be \$226K to \$589K (\$223K to \$272K), depending on the parametric assumption of risk aversion. While the returns to a college education remain high relative to the cost of a college education (both in terms of direct costs as well as foregone earnings while in school), the net gains are substantially below those commonly reported in the popular press.

In contrast to the literature on the returns to education that assesses the gain from education based on wage premiums, our utility-based calculation show that the certainty-equivalent consumption gain

from college completion has decreased in recent years. More specifically, the increase in expected earnings is offset by an increase in earnings risks, particularly the idiosyncratic permanent earnings variation.

We also find that while the value of education is larger for men in dollar terms, it is larger for women in percentage terms. Similar to the other studies in returns to education, we also find the value of education changed significantly over the past 40 years. Overall, these results show the importance of accounting for risk, preferences, and the tax-and-transfer environment when calculating the value of education. Finally it is important to mention that our analysis ignores non-monetary payoffs from education, such as happiness, longevity, improved democratic processes, lowered crime rates, or better connections (for recent reviews of this literature, see Grossman 2006, Lange and Topel 2006, Lochner 2011).

One omission in our model is that we do not account for the earnings transfers within the household that would smooth the earnings volatility and make some types of earnings shocks more “insurable” (Blundell, Pistaferri and Preston 2008, Heathcote, Storesletten and Violante 2008) than others. However, the main theme of this paper is to show that life cycle factors, preference parameters, earnings volatility, and fiscal parameters have important implications for how we think about the returns to education. While including the “insurable” risks may change the total level of risks that an agent is actually facing in the near term, it is much less likely for an individual who’s making the college attendance decision at age 18 to know how much risks would be insurable throughout the lifetime, either at the individual or at the household level. And hence, we maintain that our model is an appropriate approximation. To the extent that an individual does not have full information about the earnings risks throughout lifetime as well as how the risks can be compensated or mitigated ex-ante, our results suggest that earnings risks play important roles in the assessment of gains from education. Particularly, we show the utility-based gains from college completion actually decreased in recent years due to the increase in individual heterogeneity in permanent earnings variation.

Finally it is important to separate our work from the asset pricing literature on aggregate human capital risk. Our risk measures are those which are relevant for individual household decision making in portfolio choice models (such as, for example Cocco Gomes and Maenhout (2005)). However a significant fraction of this risk is purely idiosyncratic and therefore the discount rate on aggregate human capital should be much lower. This is indeed what is found in Lustig, Van Nieuwerburgh and Verdelhan (2013).

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## REFERENCES

- Abowd, John, and David Card, "On the Covariance Structure of Earnings and Hours Changes," *Econometrica*, 57 (1989), 411-465.
- Athreya, Kartik, and Janice Eberly, "The Education Risk Premium," Working Paper, (2011).
- Autor, David H., Lawrence F. Katz, and Melissa Kearney, "Trends in U.S. Wage Inequality: Revising the Revisionists," *Review of Economics and Statistics*, 90 (2008), 300-323.
- Autor, David H., Lawrence F. Katz, and Alan B. Krueger, "Computing Inequality: Have Computers Changed the Labor Market?," *Quarterly Journal of Economics*, 113 (1998), 1169-1213.
- Bhattacharya, Jay, and Darius Lakdawalla, "Does Medicare Benefit the Poor," *Journal of Public Economics*, 90 (2006), 277-292.
- Blundell, Richard, Luigi Pistaferri, and Ian Preston, "Consumption Inequality and Partial Insurance," *American Economic Review*, 98 (2008), 1887-1921.
- Bound, John, and Alan B. Krueger, "The Extent of Measurement Error in Longitudinal Earnings Data: Do Two Wrongs Make a Right?," *Journal of Labor Economics*, 9 (1991), 1-24.
- Cameron, Stephen, and Joseph Tracy, "Earnings Variability in the United States: An Examination Using Matched-CPS Data," Working Paper, (1998).
- Card, David, "The Causal Effect of Education on Earnings," in *Handbook of Labor Economics*, Orley Ashenfelter, and David Card, eds. (New York: Elsevier, 1999).
- Card, David, and John E. DiNardo, "Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles," *Journal of Labor Economics*, 20 (2002), 733-783.

- Carroll, Christopher, "Buffer-Stock Saving and the Life-Cycle/Permanent Income Hypothesis," *Quarterly Journal of Economics*, 112 (1997), 1-55.
- Carroll, Christopher, and Andrew Samwick, "The Nature of Precautionary Wealth," *Journal of Monetary Economics*, 40 (1997), 41-71.
- Chen, Stacey H., "Estimating the Variance of Wages in the Presence of Selection and Unobserved Heterogeneity," *Review of Economics and Statistics*, 90 (2008), 275-289.
- Cocco, João, Francisco Gomes, and Pascal Maenhout, "Portfolio Choice over The Life Cycle," *Review of Financial Studies*, 18 (2005), 491-533.
- Cunha, Flavio, and James J. Heckman, "The Evolution of Inequality, Heterogeneity and Uncertainty in Labor Earnings in the U.S. Economy," NBER Working Paper No. 13526, (2007).
- Cunha, Flavio, James J. Heckman, and Salvador Navarro, "Separating Uncertainty from Heterogeneity in Life Cycle Earnings," *Oxford Economic Papers*, 57 (2005), 191-261.
- Davis, Steven J., Felix Kubler, and Paul Willen, "Borrowing Costs and the Demand for Equity over the Life Cycle," *Review of Economics and Statistics*, 88 (2006), 348-362.
- Dynan, Karen E., Douglas W. Elmendorf, and Daniel E. Sichel, "The Evolution of Household Income Volatility," Working Paper, (2012).
- Goldin, Claudia, and Lawrence F. Katz, "The Race between Education and Technology: The Evolution of U.S. Educational Wage Differentials, 1890 to 2005," NBER Working Paper No. 12984, (2007).
- Gomes, Francisco, and Alexander Michaelides, "Optimal Life-Cycle Asset Allocation: Understanding the Empirical Evidence," *Journal of Finance*, 60 (2005), 869-904.

- Gottschalk, Peter, and Robert A. Moffitt, "The Growth of Earnings Instability in the U.S. Labor Market," *Brookings Papers on Economic Activity*, 1994 (1994), 217-254.
- Gourinchas, Pierre-Olivier, and Jonathan Parker, "Consumption Over the Life Cycle," *Econometrica*, 70 (2002), 47-89.
- Grossman, Michael, "Education and Nonmarket Outcomes," in *Handbook of the Economics of Education*, Eric A. Hanushek, and Finis Welch, eds. (Elsevier, 2006).
- Guvenen, Fatih, "An Empirical Investigation of Labor Income Processes," *Review of Economic Dynamics*, 12 (2009), 58-79.
- Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante, "Insurance and Opportunities: A Welfare Analysis of Labor Market Risk," *Journal of Monetary Economics*, 55 (2008), 501-525.
- Heckman, James J., Lance J. Lochner, and Petra E. Todd, "Earnings Functions, Rates of Return and Treatment Effects: The Mincer Equation and Beyond," in *Handbook of the Economics of Education*, Eric A. Hanushek, and Finis Welch, eds. (Elsevier, 2006).
- Hubbard, R. Glenn, Jonathan Skinner, and Stephen Zeldes, "The Importance of Precautionary Motives in Explaining Individual and Aggregate Saving," *Carnegie-Rochester Conference Series on Public Policy*, 40 (1994), 59-125.
- , "Precautionary Saving and Social Insurance," *Journal of Political Economy*, 103 (1995), 360-399.
- Huggett, Mark, and Greg Kaplan, "The Money Value of a Man," NBER Working Paper No. 18066, (2012).
- Huggett, Mark, Gustavo Ventura, and Amir Taroni, "Human Capital and Earnings Distribution Dynamics," *Journal of Monetary Economics*, 53 (2006), 265-290.



- Ionescu, Felicia, "Risky Human Capital and Alternative Bankruptcy Regimes for Student Loans," *Journal of Human Capital*, 5 (2011), 153-206.
- Jensen, Shane T., and Stephen H. Shore, "Changes in the Distribution of Income Volatility," Working Paper, (2008).
- Katz, Lawrence F., and Kevin M. Murphy, "Changes in Relative Wages, 1963–1987: Supply and Demand Factors," *Quarterly Journal of Economics*, 107 (1992), 35-78.
- Katz, Lawrence F., and David H. Autor, "Changes in the Wage Structure and Earnings Inequality," in *Handbook of Labor Economics*, Orley Ashenfelter, and David Card, eds. (New York: Elsevier, 1999).
- Krueger, Alan B., "How Computers Have Changed the Wage Structure: Evidence from Microdata 1984-1989," *Quarterly Journal of Economics*, 108 (1993), 33-61.
- Lange, Fabian, and Robert Topel, "The Social Value of Education and Human Capital," in *Handbook of the Economics of Education*, Eric A. Hanushek, and Finis Welch, eds. (Elsevier, 2006).
- Lemieux, Thomas, "Increasing Residual Wage Inequality: Composition Effects, Noisy Data, or Rising Demand for Skill?," *American Economic Review*, 96 (2006), 461-498.
- Lochner, Lance J., "Nonproduction Benefits of Education: Crime, Health, and Good Citizenship," in *Handbook of the Economics of Education*, Eric A. Hanushek, and Finis Welch, eds. (Elsevier, 2011).
- Low, Hamish, Costas Meghir, and Luigi Pistaferri, "Wage Risk and Employment Risk over the Life Cycle," *American Economic Review*, 100 (2010), 1432-1467.
- Lustig, Hanno, Stijn Van Nieuwerburgh, and Adrien Verdelhan, "The Wealth-Consumption Ratio," *Review of Asset Pricing Studies*, 3 (2013), 38-94.

- MaCurdy, Thomas E., "The Use of Time Series Processes to Model the Error Structure of Earnings in a Longitudinal Data Analysis," *Journal of Econometrics*, 18 (1982), 83-144.
- McCall, Brian P., "Unemployment Insurance Rules, Joblessness, and Part-Time Work," *Econometrica*, 64 (1996), 647-682.
- Meyer, Bruce D., "Unemployment Insurance and Unemployment Spells," *Econometrica*, 58 (1990), 757-782.
- Mincer, Jacob, *Schooling, Experience, and Earnings* (New York: NBER Press, 1974).
- Moffitt, Robert A., and Peter Gottschalk, "Trends in the Transitory Variance of Male Earnings: Methods and Evidence," *Journal of Human Resources*, 47 (2012), 204-236.
- Padula, Mario, and Luigi Pistaferri, "Education, Employment and Wage Risk," Working Paper, (2005).
- Restuccia, Diego, and Carlos Urrutia, "Intergenerational Persistence of Earnings: The Role of Early and College Education," *American Economic Review*, 94 (2004), 1354-1378.
- Staiger, Douglas, and James H. Stock, "Instrumental Variables Regression with Weak Instruments," *Econometrica*, 65 (1997), 557-586.

TABLE I  
Descriptive Statistics, PSID Household Head Aged 20-65

Panel A					
	No High School	High School Graduates	College Graduates		
Number of Agents	2,094	4,247	1,644		
Total Number of Observations	16,463	38,985	17,553		
Avg. No. of Records Per Agent	7.86	9.17	10.67		
Panel B					
Year	Proportion of Male	Age	Years of Education	Pre-Tax Labor Income in 2010 USD	Number of Agents
1971	85.22%	43.64	11.03	\$48,764	1,451
1981	80.35%	40.21	12.20	\$47,401	1,903
1991	77.06%	40.08	12.75	\$46,697	1,956
2001	75.64%	41.42	12.95	\$54,625	2,350

TABLE II  
Variance Decomposition

Panel A: Labor Income Only			
	No High School	High School Graduates	College Graduates
$\sigma_\varepsilon$ (Transitory)	0.339 (0.019)	0.234 (0.008)	0.230 (0.009)
$\sigma_u$ (Permanent)	0.157 (0.003)	0.137 (0.001)	0.144 (0.002)
Panel B: Labor Income Plus Unemployment Income			
	No High School	High School Graduates	College Graduates
$\sigma_\varepsilon$ (Transitory)	0.385 (0.018)	0.282 (0.011)	0.263 (0.011)
$\sigma_u$ (Permanent)	0.169 (0.003)	0.138 (0.002)	0.145 (0.002)

Note: Numbers are standard deviations of the variance components with clustered standard errors in parentheses.

TABLE III  
 Expected Post-Tax Labor Income, Unemployment Rate, Post-Tax Unemployment Income and  
 Replacement Rate of Average Employed Worker's Income, by Levels of Education

	No High School	High School Graduates	College Graduates
Expected Annual Labor Income without Unemployment Spells in a Year	\$29,603.79	\$37,199.99	\$60,159.39
Likelihood of Experiencing Unemployment in a Year	20.24%	14.38%	7.38%
Expected Annual Labor plus Unemployment Income with Unemployment	\$23,362.72	\$26,106.07	\$31,646.39
Replacement Rate of Income, with versus without Unemployment	78.91%	70.17%	52.06%
Expected Annual Social Security Earnings upon Retirement	\$17,780.00	\$21,532.00	\$27,169.00
Replacement Rate of Retirement Earnings	60.05%	57.88%	45.16%

TABLE IV  
Gains from Education: Expected Lifetime Earnings

Panel A: Pre-Tax Lifetime Labor Earnings between Age 22 and 65, without Adjustment for Likelihood of Unemployment, No Discount			
Education Level	Lifetime Earnings	Earnings Gain	Percentage Gain
No High School	\$1,440,293	--	--
High School	\$1,861,927	\$421,634	29.27%
College	\$3,193,106	\$1,331,809	71.52%
Panel B: Discounted Pre-Tax Lifetime Labor Earnings between Age 22 and 65, without Adjustment for Likelihood of Unemployment (Discount Rate = 1%)			
Education Level	Lifetime Earnings	Earnings Gain	Percentage Gain
No High School	\$1,167,695	--	--
High School	\$1,502,833	\$335,138	28.70%
College	\$2,536,631	\$1,033,798	68.78%
Panel C: Discounted Post-Tax Lifetime Labor Earnings between Age 22 and 65, without Adjustment for Likelihood of Unemployment (Discount Rate = 1%)			
Education Level	Lifetime Earnings	Earnings Gain	Percentage Gain
No High School	\$967,556	--	--
High School	\$1,222,955	\$255,399	26.39%
College	\$1,957,483	\$734,528	60.06%
Panel D: Discounted Post-Tax Lifetime Labor Earnings between Age 22 and 65, with Adjustment for Likelihood of Unemployment (Discount Rate = 1%)			
Education Level	Lifetime Earnings	Earnings Gain	Percentage Gain
No High School	\$926,845	--	--
High School	\$1,180,433	\$253,888	27.39%
College	\$1,894,822	\$714,389	60.51%
Panel E: Discounted Post-Tax Lifetime Labor Earnings between Age 22 and 65 plus Social Security Earnings between Age 66 and 100, with Adjustment for Likelihood of Unemployment between Age 22 and 65 (Discount Rate = 1%)			
Education Level	Lifetime Earnings	Earnings Gain	Percentage Gain
No High School	\$1,070,154	--	--
High School	\$1,353,986	\$283,832	26.52%
College	\$2,113,804	\$759,818	56.11%

Note: All numbers in panels A through E are adjusted for likelihood of survival based on the Social Security 1945 cohort mortality table.

TABLE V

Gains from Education in the Baseline Case (Risk Aversion Equal to 2 and Discount Rate Equal to 0.99)

Panel A: Without unemployment risk or income risk				
Education Level	Consumption CE	Percentage Gain	Total Wealth CE	Total Wealth CE Increase
No High School	\$30,743	--	\$1,314,849	--
High School	\$35,976	17.02%	\$1,538,660	\$223,811
College	\$52,788	46.73%	\$2,257,693	\$719,033
Panel B: Baseline				
Education Level	Consumption CE	Percentage Gain	Total Wealth CE	Total Wealth CE Increase
No High School	\$18,526	--	\$792,340	--
High School	\$24,109	30.14%	\$1,031,119	\$238,779
College	\$34,425	42.79%	\$1,472,325	\$441,206
Panel C: With Adjusted Volatilities				
Education Level	Consumption CE	Percentage Gain	Total Wealth CE	Total Wealth CE Increase
No High School	\$20,174	--	\$862,823	--
High School	\$25,713	27.46%	\$1,099,721	\$236,898
College	\$37,123	44.37%	\$1,587,716	\$487,995

Note: In Panel C we report results for the case in which the estimated volatilities were scaled down by  $\frac{3}{4}$  to take into account for potential measurement error.

TABLE VI  
Gains from Education for Different Values of the Preference Parameters, with Unemployment and  
Income Risks

Panel A: High School Education				
Education Level	$\gamma$	$\beta$	Total Wealth CE Gain	Wealth Percentage Gain
High School	1	0.97	\$230,098	23.01%
High School	1	0.99	\$223,853	22.35%
High School	2	0.97	\$234,289	28.85%
High School	2	0.99	\$238,779	30.14%
High School	4	0.97	\$272,995	62.29%
High School	4	0.99	\$267,264	71.43%
Panel B: College Education				
Education Level	$\gamma$	$\beta$	Total Wealth CE Gain	Wealth Percentage Gain
College	1	0.97	\$543,509	44.18%
College	1	0.99	\$589,315	48.08%
College	2	0.97	\$414,475	39.61%
College	2	0.99	\$441,206	42.79%
College	4	0.97	\$246,820	34.70%
College	4	0.99	\$226,676	35.34%



TABLE VII  
Variance Decomposition by Different Sub-periods

Panel A: 1968-1980			
	No High School	High School Graduates	College Graduates
$\sigma_\varepsilon$ (Transitory)	0.306 (0.011)	0.191 (0.006)	0.200 (0.008)
$\sigma_u$ (Permanent)	0.142 (0.002)	0.128 (0.001)	0.085 (0.001)
Panel B: 1980-1990			
	No High School	High School Graduates	College Graduates
$\sigma_\varepsilon$ (Transitory)	0.295 (0.030)	0.227 (0.010)	0.201 (0.007)
$\sigma_u$ (Permanent)	0.189 (0.005)	0.133 (0.002)	0.133 (0.001)
Panel C: 1991-2011			
	No High School	High School Graduates	College Graduates
$\sigma_\varepsilon$ (Transitory)	0.443 (0.049)	0.281 (0.012)	0.287 (0.014)
$\sigma_u$ (Permanent)	0.153 (0.009)	0.123 (0.002)	0.159 (0.002)

Note: Numbers are standard deviations of the variance components with clustered standard errors in parenthesis. Calculated with labor earnings only using agent-year records with no unemployment spells in a given year.

TABLE VIII  
Gains from Education: Expected Lifetime Earnings by Different Sub-periods

Panel A: 1968-1980			
Education Level	Lifetime Earnings	Earnings Gain	Percentage Gain
No High School	\$1,118,181	--	--
High School	\$1,454,240	\$336,059	30.05%
College	\$2,035,471	\$581,231	39.96%
Panel B: 1980-1990			
Education Level	Lifetime Earnings	Earnings Gain	Percentage Gain
No High School	\$1,016,068	--	--
High School	\$1,324,399	\$308,331	30.34%
College	\$2,052,730	\$728,331	54.99%
Panel C: 1991-2011			
Education Level	Lifetime Earnings	Earnings Gain	Percentage Gain
No High School	\$1,022,049		
High School	\$1,333,992	\$311,943	30.52%
College	\$2,165,107	\$831,115	62.30%

Note: The Table reports discounted Post-Tax Lifetime Labor Earnings between Age 22 and 65 plus Social Security Earnings between Age 66 and 100, with Adjustment for Likelihood of Unemployment between Age 22 and 65 (Discount Rate = 1%), and adjustment for likelihood of survival based on the Social Security 1945 cohort mortality table.

TABLE IX  
Gains from Education in the Baseline Case (Risk Aversion Equal to 2 and Discount Rate Equal to 0.99),  
by Different Sub-Periods

Panel A: 1968-1980			
Education Level	Total Wealth CE	Total Wealth CE Increase	Percentage Gain
No High School	\$818,551	--	--
High School	\$1,146,274	\$327,723	40.04%
College	\$1,634,199	\$487,925	42.57%
Panel B: 1981-1990			
Education Level	Total Wealth CE	Total Wealth CE Increase	Percentage Gain
No High School	\$647,674	--	--
High School	\$955,534	\$307,860	47.53%
College	\$1,393,585	\$438,051	45.84%
Panel C: 1991-2011			
Education Level	Total Wealth CE	Total Wealth CE Increase	Percentage Gain
No High School	\$692,559	--	--
High School	\$997,118	\$304,558	43.98%
College	\$1,390,251	\$393,133	39.43%

TABLE X  
Variance Decomposition by Gender Subsamples

Panel A: Men			
	No High School	High School Graduates	College Graduates
$\sigma_\varepsilon$ (Transitory)	0.325 (0.019)	0.231 (0.008)	0.229 (0.010)
$\sigma_u$ (Permanent)	0.146 (0.003)	0.132 (0.001)	0.140 (0.002)
Panel B: Women			
	No High School	High School Graduates	College Graduates
$\sigma_\varepsilon$ (Transitory)	0.382 (0.030)	0.264 (0.011)	0.252 (0.023)
$\sigma_u$ (Permanent)	0.221 (0.005)	0.184 (0.002)	0.171 (0.004)

Note: Numbers are standard deviations of the variance components with clustered standard errors in parenthesis. Calculated with labor earnings only using agent-year records with no unemployment spells in a given year.

TABLE XI  
Gains from Education: Expected Lifetime Earnings by Gender

Panel A: Men			
Education Level	Lifetime Earnings	Earnings Gain	Percentage Gain
No High School	\$1,175,446	--	--
High School	\$1,450,272	\$274,826	23.38%
College	\$2,232,375	\$782,103	53.92%
Panel B: Women			
Education Level	Lifetime Earnings	Earnings Gain	Percentage Gain
No High School	\$648,446	--	--
High School	\$978,698	\$330,252	50.92%
College	\$1,392,265	\$413,567	42.25%

Note: The Table reports discounted Post-Tax Lifetime Labor Earnings between Age 22 and 65 plus Social Security Earnings between Age 66 and 100, with Adjustment for Likelihood of Unemployment between Age 22 and 65 (Discount Rate = 1%), and adjustment for likelihood of survival based on the Social Security 1945 cohort mortality table.

TABLE XII  
Gains from Education in the Baseline Case (Risk Aversion Equal to 2 and Discount Rate Equal to 0.99),  
by Gender

Panel A: Men			
Education Level	Total Wealth CE	Total Wealth CE Increase	Percentage Gain
No High School	\$900,058	--	--
High School	\$1,102,099	\$202,041	22.45%
College	\$1,532,007	\$429,907	39.01%
Panel B: Women			
Education Level	Total Wealth CE	Total Wealth CE Increase	Percentage Gain
No High School	\$333,418	--	--
High School	\$626,775	\$293,357	87.98%
College	\$970,374	\$343,600	54.82%

Figure I  
Labor Income Profile over Age

