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Risk and the distribution of human capital

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Abstract

We developed a model in which aggregate production risk determines the average level of education and its distribution. Greater risk is associated with greater educational inequality and a lower average attainment. An empirical test using panel data supports this conclusion.

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1. Introduction

Recent empirical studies have shown that macroeconomic volatility affects a number of macroeconomic variables. Greater volatility has been found to reduce the average growth rate and secondary schooling enrolment rates, while it tends to increase income inequality (see, respectively, [Ramey and Ramey, 1995](#); [Flug et al., 1998](#); [Breen and García-Peñalosa, 2002](#)). In this paper, we examine a further possible effect of volatility, namely its effect on the distribution of human capital.

We start by presenting a model, which extends the seminal work of [Glor and Zeira \(1993\)](#) by introducing uncertainty. In principle, uncertainty has an ambiguous effect on individual incentives to study. [Levhari and Weiss \(1974\)](#) show that there are two sufficient conditions under which greater risk reduces investment in education: that the variance of earnings is increasing with the level of schooling, and that agents have decreasing absolute risk-aversion. Our model makes both assumptions, implying

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that economies that are more volatile exhibit fewer average years of education and a greater degree of educational inequality. Furthermore, under these assumptions, greater non-labour wealth raises educational investment; a result we use to link the initial distribution of wealth to long-run educational inequality. The long-run distribution of human capital then depends on aggregate production risk and initial inequality.

The second part of the paper provides empirical evidence on a positive relationship between output volatility and educational inequality, examining the variables correlated with educational achievement and its distribution in a sample of countries. Closest to our work is Flug et al. (1998). They find a negative correlation between secondary school enrolment rates and growth volatility and argue that the financial constraints caused by downturns affect *flows* into education. Our model is concerned with the long-run behaviour of the economy and hence seeks to explain the determinants of the *stock* of education. Furthermore, we are not only interested in explaining average educational attainment but also its distribution.

2. The model

2.1. Elements of the economy

2.1.1. Firms

Firms produce according to

$$Y_t = A_t K_t^\beta L_t^{1-\beta}, \quad 0 < \beta < 1, \quad (2.1)$$

where K_t is the capital stock, and L_t the number of efficiency units of labour. There are two types of labour, unskilled, u_t , and skilled, s_t , which supply 1 and h efficiency units of labour, respectively, so that $L_t = u_t + s_t h$. A_t represents the level of productivity at time t , common to all firms. It can take values \bar{A} and \underline{A} , each with probability 1/2, where $\bar{A} > \underline{A}$. It has mean $\mu = (\bar{A} + \underline{A})/2$ and variance $\sigma^2 = \mu^2 - \bar{A}\underline{A}$.

Firms decide on their stock of capital before the shock is realised, but pay wages after production takes place. They are risk neutral, hence they equate the (given) world interest rate, r , to the expected marginal product of capital. This implies a constant capital labour ratio, and a wage per efficiency unit in period t of $\omega_t = A_t w$, where w is a constant.¹

2.1.2. Consumers

The population is normalised to one. Each consumer lives for two periods; chooses whether or not to study in the first one, and works in the second. Her entire consumption, c , takes place in the second period, and she also leaves a bequest b to her offspring. The utility of agent i is

$$U_{it} = (1 - \alpha) \ln c_{it} + \alpha \ln b_{it}. \quad (2.2)$$

¹ Specifically, $K_t/L_t = (\mu\beta/r)^{1/(1-\beta)}$ and $w = (1-\beta) (\mu\beta/r)^{\beta/(1-\beta)}$.

Denote her income by Y_{it} . She then maximises her expected utility,

$$\max EU_{it} = \frac{1}{2} [(1 - \alpha) \ln \bar{c}_{it} + \alpha \ln \bar{b}_{it}] + \frac{1}{2} [(1 - \alpha) \ln \underline{c}_{it} + \alpha \ln \underline{b}_{it}] \quad (2.3)$$

subject to

$$\bar{Y}_{it} = \bar{c}_{it} + \bar{b}_{it}$$

$$\underline{Y}_{it} = \underline{c}_{it} + \underline{b}_{it}$$

where a bar above (below) a variable indicates its value in the good (bad) state of the world. The solution to this problem implies that, at any time, a fraction of income α is bequeathed and a fraction $(1 - \alpha)$ consumed.

2.1.3. Education

In the first period of life, an agent born at time t decides whether or not to study. There is a fixed education cost, f , which can be funded with the inheritance received at birth from her parent, $x_{it} = b_{it-1}$, or by borrowing in the perfect capital market. An individual who chooses not to study works as unskilled labour in the second period of life. Alternatively, she pays the cost f , acquires n years of education, and works as a skilled worker. The expected utilities of being unskilled or skilled are, respectively,

$$EU_{it}^u = \ln(1 - \alpha)^{1-\alpha} \alpha^\alpha + \frac{1}{2} \ln[\bar{A}w + Rx_{it}] + \frac{1}{2} \ln[\underline{A}w + Rx_{it}] \quad (2.4)$$

$$EU_{it}^s = \ln(1 - \alpha)^{1-\alpha} \alpha^\alpha + \frac{1}{2} \ln[\bar{A}hw + R(x_{it} - f)] + \frac{1}{2} \ln[\underline{A}hw + R(x_{it} - f)] \quad (2.5)$$

where $R \equiv 1 + r$. An agent chooses to study if her expected utility from doing so exceeds that of remaining unskilled. That is, if her inheritance is greater than x^* , where

$$x^* \equiv \frac{1}{2R} \frac{Rf[2\mu hw - Rf] - (\mu^2 - \sigma^2)w^2(h^2 - 1)}{\mu(h - 1)w - Rf} \quad (2.6)$$

Inheritance plays the role of insurance. Since agents have decreasing absolute risk-aversion, and since the absolute level of risk associated with becoming skilled is greater than that associated with remaining unskilled, they chose to study only if they have a sufficiently large non-risky income.

2.2. The long-run wealth levels

The dynamics of bequests for the skilled and unskilled are given by

$$x_{it+1}^u = \alpha[A_t w + R x_{it}] \quad (2.7)$$

$$x_{it}^s = \alpha[A_t h w + R(x_{it} - f)] \quad (2.8)$$

implying upward-sloping relationships between x_{it} and x_{it+1} , as depicted in Fig. 1. Since the technology parameter can take two values, there are two lines along which each type of worker can move, represented by the continuous lines. With probability 1/2, there is a good state, and an individual moves along the upper line; with probability 1/2 she moves along the lower one, corresponding to a bad state. Assuming $\alpha R < 1$, these lines will intersect the 45° line. All dynasties with initial wealth $x_{i0} < x^*$ remain unskilled, and converge to the same long-run bequest, which is stochastic. It fluctuates between the two fixed points defined by Eq. (2.7), $\underline{x}^u = \alpha \underline{A} w / (1 - \alpha R)$ and $\bar{x}^u = \alpha \bar{A} w / (1 - \alpha R)$, has mean $E(x^u) = \alpha \mu w / (1 - \alpha R)$ and variance $\sigma_u^2 = (\alpha w)^2 \sigma^2 / (1 - R^2)$. Similarly, all

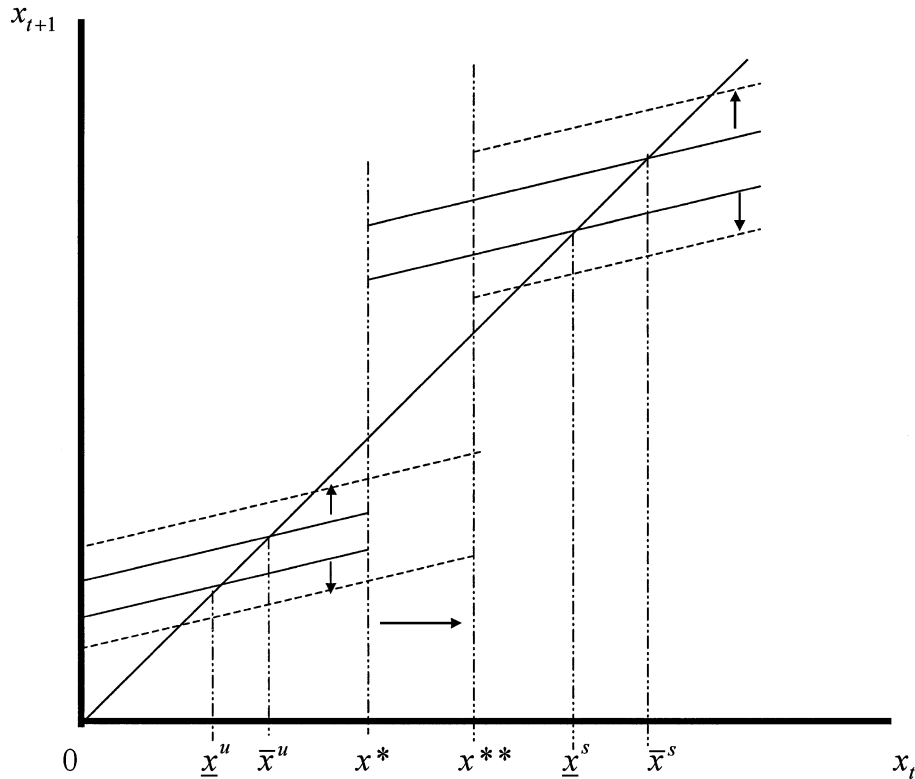


Fig. 1. The dynamics of bequests.

members of dynasties with initial wealth above x^* are educated and have long-run bequests that fluctuate between \underline{x}^s and \bar{x}^s , have mean $E(x^s) = (\alpha\mu hw - \alpha Rf)/(1 - \alpha R)$ and variance $\sigma_s^2 = (\alpha hw)^2 \sigma^2 / (1 - R^2)$.²

Given an initial distribution of bequests, $F(x)$, the long-run number of skilled workers will be given by $1 - F(x^*)$. Then, the stock of efficiency labour is $L = F(x^*) + (1 - F(x^*))h$, and average years of education are $\overline{HC} = n(1 - F(x^*))$. As we show in the next section, with only two education levels the Gini coefficient of the distribution of years of education is simply $F(x^*)$. The initial distribution of income thus determines both average educational attainment and the degree of educational inequality.

2.3. The effect of risk

Suppose that there is a mean-preserving spread (MPS), which increases \bar{A} and reduces \underline{A} , increasing the variance of the technology. Greater risk has two effects. First, the change in \bar{A} and \underline{A} will shift the bequest schedules of each group further apart, to the discontinuous lines in Fig. 1. Although the mean bequests of the skilled and the unskilled remain constant, their variance over time rises. Because the level of earnings of educated workers is higher, the increase in the variance of both earnings and bequests is greater for educated than for non-educated individuals. Second, risk will affect the number of individuals that study. Differentiating Eq. (2.6), we see that the increase in \bar{A} increases the threshold value of inheritance required to study to $x^{**} > x^*$. Although uncertainty has increased for both types of workers, it has increased by more for educated than for uneducated workers, hence, greater wealth is needed in order to study. Given the initial distribution of wealth, the long-run number of educated workers falls to $1 - F(x^{**})$. An economy with greater risk will then exhibit a lower stock of efficiency labour (and hence lower output), fewer average years of education, and a more unequal distribution of human capital.

3. Empirical results

3.1. Measures of educational inequality and attainment

We measure the degree of educational inequality by the Gini concentration index computed across subgroups of population, Gini_{ed} . When only subgroup averages are known (as it is the case with educational variables, where individuals are grouped according to their education certificate), the definition of the Gini concentration index is:

$$\text{Gini}_{\text{ed}} = \frac{1}{2\overline{HC}} \sum_{k=1}^M \sum_{h=1}^M |\bar{n}_k - \bar{n}_h| \text{HC}_k \text{HC}_h \quad (3.1)$$

² There are other possible configurations for the position of the four bequest lines. In those cases, at least one of the schedules would not intersect the 45° line. This would mean mobility, in the sense that a dynasty that was initially not educated can, in the presence of a good shock, become educated, or vice versa. Since there is no other source of heterogeneity in the model, this would imply that in the long run all individuals would have the same level of wealth and education, and all inequalities would disappear.

Table 1
Descriptive statistics—weighed average (weights = population)—1960–95

Variable	Mean	S.D.	Min	Max	Countries, max sample	Observations, max sample
GINIED	49.62	23.85	5.10	99.52	117	848
HC	4.56	2.80	0.04	12	111	775
GDP	4025.04	4532.0	288	24,979.3	111	775
SDGDP	4.89	2.07	1.74	15.57	111	775
AVGINI	38.70	7.74	23.93	62.23	96	685
KY	2.36	0.63	0.36	7.43	85	625
LLY	0.392	0.24	0.10	1.50	90	662

GINIED = Gini index of educational attainment (see Eq. (3.1)), HC = Average educational attainment in the population—years of schooling (see Eq. (3.2)), GDP = Gross domestic product per capita (1985 US dollar), SDGDP = Average of 3-year moving standard deviation of growth rate of GDP over 1960–1990, AVGINI = Gini index of income inequality—country means (corrected for recipient unit and income/consumption), KY = Physical capital/output ratio, LLY = liquid liability over GDP (average over the period 1960–1989).

where M is the number of subgroups, and \bar{n}_h is the (average) educational attainment in subgroup h , which has relative weight HC_h . The average number of years of schooling in the population is defined as

$$\overline{HC} = \sum_{k=1}^M \bar{n}_k HC_k. \quad (3.2)$$

These two measures are negatively correlated. To illustrate this, consider a population with two groups: one has 0 years of education and dimension $(1 - HC)$, while the other has n years of education. Average educational attainment is simply $\overline{HC} = nHC$, and educational inequality is given by

$$\text{Gini}_{ed} = \frac{2[|n - 0|HC(1 - HC)]}{2nHC} = (1 - HC). \quad (3.3)$$

The negative correlation holds when we move to three groups in the population, although additional assumptions are required.³

3.2. Data sources and empirical strategy

Our education measures are derived from Barro and Lee (1996), which we have extended up to 1995. Data on GDP and its volatility are obtained from the Penn World Tables 5.6 (Summers and Heston, 1991) extended to 1995 using UNDP (2001). Data on income inequality are from Deininger and Squire (1996), data on physical capital stocks from Nehru and Dhareshwar (1993), and data on liquidity measures from King and Levine (1993). Descriptive statistics are reported in Table 1. In our largest sample, we cover 111 countries in 5-year intervals over 1960–1995.

³ See Checchi (2001), Appendix 3, for a proof.

Table 2
Determinants of average educational attainment—1960–1995

# Count:	11	80	73	111	80	73
# Obs:	775	597	547	775	597	547
Depvar:	hc	hc	hc	hc	hc	hc
sdgdp	−0.362** (−2.95)	−0.203* (−2.31)	−0.204* (−2.35)	−0.211* (−2.49)	−0.228** (−2.66)	−0.256** (−2.74)
avgini		−0.121* (−2.52)	−0.134** (−2.73)		−0.083** (−2.73)	−0.091** (−3.13)
log(gdp)				2.383** (7.13)	2.231** (6.95)	2.595** (5.52)
lly		3.286** (3.02)	2.701* (2.36)			−1.823 (−1.65)
ky			0.553** (2.60)			0.458* (2.13)
R ²	0.668	0.771	0.778	0.84	0.854	0.864

Weighed OLS (weights=population)—White-Huber robust standard errors clustered errors (cluster=country) *t* statistics in parentheses with $p < 0.05 = *$, $p < 0.01 = **$.

Unfortunately, not all our variables have a temporal dimension. First, we measure aggregate risk by the volatility of growth over the period 1960–1990. We measure volatility over a long period because our model is concerned about predicted or long-term risk. Short-term measures would not capture this concept, but rather be a measure of shocks. Second, we proxy the initial distribution of wealth by the distribution of income in a country averaged over the entire period. Using contemporaneous values is not possible as the distribution of income depends on that of education and we would have an endogeneity problem (see Checchi, 2001; Castelló and Domenech, 2002). Using lagged values would have discarded a very large number of observations, since the panel on income distribution presents many gaps.

Given the impossibility of using a country fixed-effect estimator because of the presence of country averages, we resort to using a population-weighted least-square estimator, with robust and country-clustered standard errors.⁴ The main drawback of this empirical strategy is that causality between volatility and inequality is not clear, a general problem of these types of cross-section analyses. We control for years and broad regions in all regression equations.

3.3. Results

Our estimates are reported in Tables 2 and 3. We start with the largest available sample, showing the negative correlation between aggregate risk and average educational attainment, and the positive one between volatility and the Gini coefficient. We then introduce measures of financial depth and the Gini of income. Financial depth is as a proxy for capital market imperfections, which would tend to reduce average attainment and increase educational inequality, as in Galor and Zeira (1993). Both variables have the expected signs.

⁴ The alternative we have considered is using a population average GEE estimator with robust standard errors. Results are similar, with more statistical significance in HC regressions and less significance in GINIED regressions. Estimates are available from the authors.

Table 3
Determinants of educational inequality—1960–1995

# Count:	11	80	73	111	80	73
# Obs:	775	597	547	775	597	547
Depvar:	ginied	ginied	ginied	ginied	ginied	ginied
sdgdp	2.617** (2.87)	1.485* (2.12)	1.463* (2.14)	1.682* (2.54)	1.830** (2.78)	1.771** (2.75)
avgini		0.727* (2.00)	0.806* (2.16)		0.50 (1.85)	0.546* (2.01)
log(gdp)				– 16.784** (– 7.93)	– 15.875** (– 7.68)	– 15.485** (– 6.45)
lly		– 28.642** (– 3.92)	– 23.983** (– 3.12)			3.015 (0.49)
ky			– 4.328* (– 2.30)			– 3.759* (– 2.00)
R ²	0.735	0.833	0.84	0.865	0.876	0.882

Weighed OLS (weights = population)—White-Huber robust standard errors clustered errors (cluster = country) *t* statistics in parentheses with $p < 0.05 = *$, $p < 0.01 = **$.

There are other factors that affect both the demand for and the supply of education. The demand for education is higher than its expected return. Direct estimates of returns to education (from [Bils and Klenow, 2000](#)) were not significant and are not reported here. A proxy for the demand of skilled workers that typically raises the return to education is the capital/output ratio. We find that this variable is positively associated with average educational attainment and negatively with educational inequality. On the supply side, we tried using the degree of urbanisation, capturing the proximity to school and (current) public expenditure on education. None of these variables proved to have a significant impact (results not reported).⁵

It is well known that a good predictor of a country's educational achievement is its level of development. We therefore control for the stage of development of each country using the (log of) current GDP per capita. Columns 4, 5, and 6 of [Tables 2 and 3](#) include this variable. The effect of volatility is robust to the inclusion of current output, with the coefficient changing only slightly. However, the coefficient on financial depth loses its significance; this is not surprising given the high correlation between per capita output and financial development both across countries and over time.

4. Concluding remarks

Recent empirical work has shown that risk matters for the behaviour of economic aggregates, such as the average growth rate. The results in this paper suggest another reason why risk has undesirable effects: the presence of uncertainty harms both average educational attainment and its distribution. The estimated coefficients indicate a strong impact: if Chile were to reduce its level of volatility to that of the U.S. (i.e. by 3.8 percentage points), average educational attainment would increase by almost 1 year and

⁵ This is in line with previous results (e.g. [Flug et al., 1998](#)) that find no impact of public expenditure on secondary education on secondary enrolment rates.

education inequality would fall by 7.9 Gini points. This suggests, not only that reducing volatility is desirable, but also the possibility of macroeconomic reforms that do not entail a conflict between efficiency and equity.

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