What is it about schooling that the labor market rewards? The components of the return to schooling

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January 8, 2008

Abstract

This paper shows that when specifically controlling for schooling cognitive skills (*i.e.* the capacity to process information and apply knowledge) and not cognitive skills as a whole, over half the return to schooling is constituted of cognitive skills. This contrasts with the previous literature that strongly favored noncognitive skills (*i.e.* behavioral and personality traits) as the key component of the return to schooling. Our results show schools are a place where one acquires, or is sorted, on a knowledge criterion and a behavioral one in equal shares. Findings also suggest that cognitive skills acquired in school are considerably more likely to be rewarded than their non-schooling counterpart. This effect may be attributed to the signaling value of schooling and to employer learning. Such conclusions give weight to current policies that employ cognitive skill tests, such as PISA, TIMMS and PIRLS, to asses schooling quality.

JEL classification: I21; J24; J31

Keywords: Schooling; Cognitive and noncognitive skills; Wages; Rate of return; Omitted variable bias; Signaling.

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This research was supported by the Leading House on the Economics of Education. This paper was presented at the Lemanic Young Researchers in Economics Seminar, Geneva, Switzerland, February 2007; the National Conference of Labour Economists, Naples, Italy, September 2007 and at the European Association of Labour Economists, Oslo, Norway, September 2007. I thank participants for their comments. I also thank Sandra Black, Ulrich Blum, Martin Carnoy, Jean-Marc Falter, Yves Flückiger, Herbert Gintis, David Green, Jennifer Hunt, Marcello Olarreaga, Daniel Pasche, Mathias Thoenig and Patrick Werquin for very helpful comments that led to revisions and clarifications.

1 Introduction

Both the human capital and signaling theories hypothesize schooling and skills are positively related, yet they differ in their causal relationship. On the one hand: "Some schools, like those for barbers, specialize in [the production of] one skill, while others, like universities, offer a large and diverse set" Becker (1994). On the other hand: "It [schooling] is productive for the individual, but, it does not increase his real marginal product at all" Spence (1971). Neither the human capital nor signaling theories specify what type of skill, cognitive or noncognitive[1], is acquired or signaled by schooling. With the notable exception of Gintis (1971) and Bowles *et al.* (2001) little research has sought to discover what actually triggers the educational earning premium. Their empirical estimates suggest less than 20% of the return to schooling can formally be attributed to cognitive skills. The balance has been attributed to noncognitive skills and not to cognitive skill mis-measurements. The size of schooling's cognitive and noncognitive components are highly relevant for policy making in the sense they allow to bring into line what is taught at school with what is rewarded on the labor market. In one believes these results schools primarily function as a place where one acquires or signals personality traits, consequently contradicting the present educational grading system based for the most part on cognitive performance.

With respect to the literature on schooling, skills and wages this paper develops an innovative methodology on finding what it is about formal education that the labor market rewards and confronts decades of both theoretical and empirical results. This original framework gives way to two contributions. First, by developing a simple model relating schooling cognitive skills, schooling noncognitive skills and non-schooling cognitive skills we demonstrate why previous estimates of schooling's components were biased and find that half the return to schooling is positively cognitive. This gives a new insight on the role of cognitive skills when determining wages and shows that today's policies that evaluate educational performance on cognitive skill scores such as PISA, PIRLS or TIMSS[2], and attempt to increase the cognitive

[1] Cognitive skills are considered as the capacity to process information and apply knowledge. Intelligence Quotient tests and the Armed Forces Qualification Test are adequate measures to asses cognitive skill proficiency. Reversely, noncognitive skills relate to behavioral, personality and physical traits. Creativity, perseverance, dependability, consistency, risk-aversion, self-esteem and leadership skills are examples of noncognitive skills.

[2] Programme for International Student Assessment, Progress in International Reading

standards of schooling are not futile, as previous research concluded. Second, by comparing the schooling cognitive skill coefficient with the non-schooling cognitive skill coefficient we develop a signaling measure. Results show that, because of asymmetry on the labor market, cognitive skills identical in nature but that originate from a schooling environment are several times more likely to be rewarded than their non-schooling counterpart. As years of experience increase the odds of schooling cognitive skills being rewarded relatively to non-schooling cognitive skills diminishes. This effect may be attributed to the signaling value of schooling and the learning of initially unobserved skills by employers.

The approach differs from previous methods used to quantify schooling's components by controlling for schooling cognitive skills separately from non-schooling cognitive skills, and not just cognitive skills as a whole. Such a distinction is done because formal education may not be a perfect screening device, nor the sole learning or signaling environment, of cognitive skills and because the return to cognitive skills may depend on their schooling and non-schooling origins. We therefore distinguish people that are highly skilled both inside and outside of school, from those that are solely skilled according to schooling standards, from those that are skilled but lack a diploma to prove it, from those that have low skills whatsoever. Alike previous papers with similar research questions this paper does not seek to disentangle the signaling and human capital puzzle, but solely to decompose the *in fine* components of the return to schooling.

Reversely to previous research we find basic cognitive skills represent more than half of the return to schooling. Furthermore obtaining or signaling cognitive skills by educational diplomas is considerably more profitable than without. In terms of economic policy including a cognitive skill measure in a schooling quality index, such as PISA, PIRLS or TIMSS and emphasizing the cognitive curricula of formal education are appropriate measures.

The paper unfolds as follows. Section 2 briefly summarizes the relevant literature. Section 3 presents the empirical model and a mathematical development of the predicted conclusions. Section 4 describes the data. Section 5 displays results. Finally, section 6 concludes.

Literacy Study and Trends in International Mathematics and Science Study.

2 Relevant literature

In this paper we borrow from various authors and combine their approaches in order to revisit previous measures of schooling's components. We purposely limit the literature review to papers used to answer our research question. A full literature review can be found in Bowles *et al.* (2001).

2.1 Determining the cognitive and noncognitive components of the return to schooling

To measure the cognitive and noncognitive components of the return to schooling they run two wage regressions. Computing the ratio of the years of schooling coefficient, when controlling for cognitive skills, to the years of schooling coefficient, when omitting cognitive skills, yields the noncognitive component of the return to schooling. The cognitive component of the return to schooling is equal to one minus the noncognitive component of the return to schooling. Using 25 American studies, Bowles *et al.* (2001) find that, on average, controlling for cognitive skills reduces the years of schooling coefficient by 18%. Cognitive skills therefore represent less than a fifth of the return to schooling. The remaining 82% of the return to schooling could either be associated with more advanced cognitive skills that are not captured by basic measures or with noncognitive skills. The authors largely favor the noncognitive skill hypothesis: "The most obvious potential problem - that the cognitive score might be measured with considerably more error than the schooling variable and hence α [the noncognitive component of the return to schooling] is upwards biased- is almost certainly not the case" Bowles *et al.* (2001) and "... these studies provide strong support for the Affective Model [noncognitive skills hypothesis], and indicate that cognitive development is not the central means by which education enhances worker success" Gintis (1971).

2.2 Splitting cognitive skills per origin

Farber and Gibbons (1996) analyze employer learning and wage dynamics. To do so they use the 1979 National Longitudinal Survey of Youth and split the cognitive skill measure between those observed by the labor market (*i.e.* schooling cognitive skills) and those unobserved by the labor market *(i.e.* non-schooling cognitive skills). Their measure of schooling cognitive skills is the fitted component from an ordinary least square regression of the total cognitive skills measure, available in the data, on variables observed by the labor market (schooling, part-time status, race, sex and age). The measure of non-schooling cognitive skills is the residual of this regression. Data shows the return to schooling skills decreases with experience. Reversely the return to non-schooling cognitive skills increases, suggesting employers learn on skills initially unobserved by the labor market.

Ishikawa and Ryan (2002) examine the relationship between schooling, schooling cognitive skills, non-schooling cognitive skills and wages by using the 1992 National Adult Literacy Survey. Their results find, for the most part, it is schooling cognitive skills that affect wages. To obtain such a result they, alike Farber and Gibbons (1996), run a two step estimation. In the first step they split the total cognitive skill measure between schooling and non-schooling cognitive skills. They regress the total cognitive measure over the number of years of schooling and schooling type dummies (*e.g.* primary school or high school)[3]. In the second step they estimate wages when controlling for schooling type, schooling cognitive skills and non-schooling cognitive skills.

3 Model

This section develops the empirical wage model, presents a measure of schooling's components, suggests a signaling measure, splits cognitive skills into a schooling and a non-schooling part, and demonstrates why previous estimates of the components of the return to schooling are biased in virtually all cases.

3.1 Wages and schooling's components

Using the variables available in our data and making use of Bowles *et al.* (2001), Ishikawa and Ryan (2002) and Tyler (2004) the model is described by figure 1. w is wages, S is years of schooling, SCS is schooling cognitive skills, $NSCS$ is non-schooling cognitive skills, A is "ability" and F is family background. We assume all relations between the variables in figure 1 are positive. The bold arrow represents the noncognitive effect of schooling on wages. The dotted arrow represents the cognitive effect of schooling

[3] Family income, geographical region, ethnic group, parents' schooling as well as reading and writing habits at home are also included as control variables.

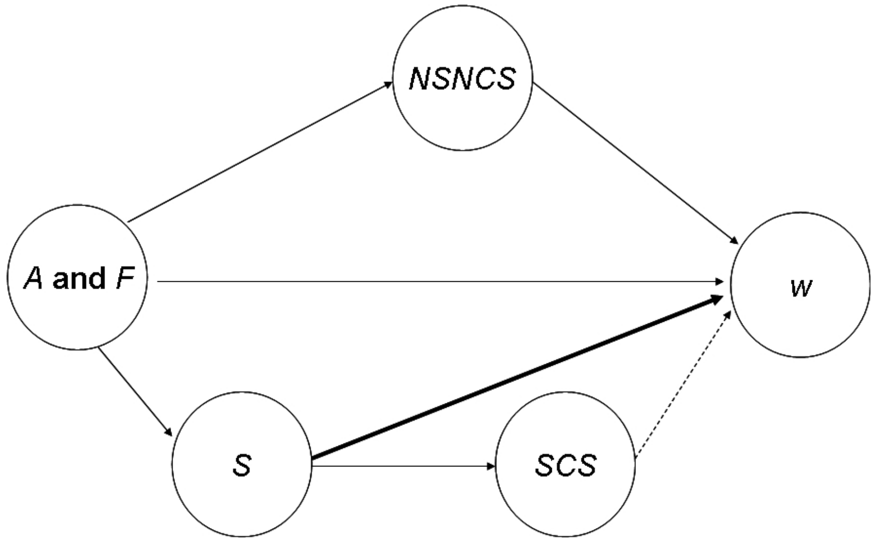

Figure 1: Model relating schooling, skills and wages

on wages. Although non-schooling noncognitive skills also influence wages, we omit them from the model because they are not available in our data. In accordance with Bowles *et al.* (2001) cognitive skills are assumed to be measured with no more error than years of schooling.

Before obtaining the model described by figure 1, we begin with the Mincerian wage equation.

$$w_i = \alpha_0 + \alpha_1 S_i + \alpha_2 X_i + \alpha_3 A_i + \alpha_4 F_i + \alpha_5 G_i + \varepsilon \qquad (1)$$

α_1 is the Mincerian return to schooling. It measures the return to both cognitive and noncognitive skills, acquired or signaled by schooling, on wages. X is a quadratic expression of years of labor experience and G a control vector for location of residence and place of birth.

Wage estimates controlling for cognitive skills are generally formulated as follows:

$$w_i = \beta_0 + \beta_1 S_i + \beta_2 TCS_i + \beta_3 X_i + \beta_4 A_i + \beta_5 F_i + \beta_6 G_i + \varepsilon \qquad (2)$$

β_2 is the return to total cognitive skills, TCS. Total cognitive skills measures all the cognitive skills an individual possess, without distinction from where they were acquired or how they are signaled. β_1 is the return to schooling when one controls for total cognitive skills.

Following the line of Gintis (1971) and Bowles *et al.* (2001) the components of the return to schooling are measured as follows:

$$\tau = \frac{\beta_1}{\alpha_1} \text{ and } \upsilon = 1 - \tau \tag{3}$$

τ is the noncognitive component of the return to schooling and υ its cognitive component. If schooling influences wages solely by increasing ones cognitive skills, τ would be zero. In this case the years of schooling coefficient, β_1, drops to zero when one controls for cognitive skills, because the effect of schooling is entirely captured by the cognitive skill variable (*i.e.* schooling noncognitive skills are not rewarded). Conversely, if the effect of schooling on cognitive skills explains none of schooling's contribution to wages τ is equal to one, because the inclusion of the cognitive skill measure does not affect the return to schooling (*i.e.* $\alpha_1 = \beta_1$).

Anticipating subsection 3.3 the ratios of equation (3) appear unbiased in only three cases: (1) cognitive skills are exclusively acquired or signaled by schooling and the return to non-schooling cognitive skills is consequently nil, (2) employers have immediate and perfect information on employees' skills and reward both schooling cognitive skills and non-schooling cognitive skills at the same rate, or (3) schooling yields no cognitive skills and their return is therefore zero.

To obtain an unbiased measure of the components of the return to schooling "The most straightforward is to ask what schools teach and to consider the economic return to the resulting curricular outcomes" Bowles *et al.* (2001). Equation (4) explicitly measures the economic return to schooling cognitive and schooling noncognitive skills:

$$w_i = \gamma_0 + \gamma_1 S_i + \gamma_2 SCS_i + \gamma_3 X_i + \gamma_4 A_i + \gamma_5 F_i + \gamma_6 G_i + \varepsilon \tag{4}$$

The years of schooling coefficient, γ_1, is the the noncognitive return to schooling (the cognitive component of schooling being captured by γ_2). SCS is the cognitive skill score based on schooling curriculum.

The noncognitive and cognitive components of the return to schooling, when controlling for schooling cognitive skills, are approximated as follows:

$$\tau' = \frac{\gamma_1}{\alpha_1} \text{ and } \upsilon' = 1 - \tau' \tag{5}$$

The specifications of equations (3) and (5) assume the average contributions of schooling cognitive skills and schooling noncognitive skills are quantitatively constant across years of schooling. This assumption, frequently found in the literature, holds on the following two arguments. First "[...] schools continually maintain their hold on students. As they "master" one type of behavioral regulation, they are either allowed to progress to the next or channeled into the corresponding level in the hierarchy of production" Bowles and Gintis (1976). Across all levels of schooling, individuals acquire noncognitive skills, from rule-following at primary school, to norm internalization at graduate level. Second, studies with data containing multiple noncognitive skill measures generally fail to identify their schooling or non-schooling origin. Despite the well known caveats that plague ordinary least square estimates, we chose to privilege such a methodology to ensure comparisons with previous estimates.

3.2 Wages and a signaling measure

Our final wage estimation includes a measure of non-schooling cognitive skills:

$$w_i = \delta_0 + \delta_1 S_i + \delta_2 SCS_i + \delta_3 NSCS_i + \delta_4 X_i + \delta_5 X_i + \delta_6 F_i + \delta_7 F_i + \delta_8 G_i + \varepsilon \quad (6)$$

The interest in equation (6) lies in comparing the schooling cognitive skill coefficient, δ_2, with the non-schooling cognitive skill coefficient, δ_3, hence leading to a signaling measure. Schooling cognitive skills and non-schooling cognitive skills are both similar in nature as they initiate from the same original total cognitive skill measure. Their sole dissimilarity is how they are signaled to employers. Differences between δ_2 and δ_3 should not be interpreted as a difference in the rate of return between these skills, but as a disparity in the odds of them being observed and consequently rewarded by the labor market.

Equation (7) informs us on the odds schooling cognitive skills have in being rewarded over non-schooling cognitive skills:

$$\omega = \frac{\delta_2}{\delta_3} \quad (7)$$

ω is presumably larger than 1 because information is never free nor immediately obtained. Schooling cognitive skills, δ_2, are immediately rewarded as they are immediately observed by employers. Assuming employers learn, non-schooling cognitive skills are gradually rewarded by the labor market, ω decreases over time. See Farber and Gibbons (1996), Altonji and Pierret (2001) and Lange (2007) for empirical evidence of employer learning.

3.3 Cognitive skills per origin

The challenge when estimating equation (4) is that the schooling cognitive skill measure are generally not available in data. To obtain such a measure we borrow from Farber and Gibbons (1996) and Ishikawa and Ryan (2002):

$$TCS_i = \theta_0 + \theta_1 ST_i + \nu \tag{8}$$

Equation (8) is explicitly asking what school's teach, or signal, in terms of cognitive skills. Using the schooling type dummies, ST, (*e.g.* high school diploma or bachelor's degree) allows us to control for the effects of schooling types on cognitive skills.

Using the coefficients obtained in equation (8) we obtain a measure of schooling cognitive skills. In order to know what cognitive skills are acquired or signaled in school we do not need to establish a causal relation, but solely a correlation[4]. Equation (9) informs us that people with a given schooling degree have a given cognitive skill level, but does not disentangle the signaling and human capital puzzle.

$$SCS_i = E(TCS_i|ST_i) \tag{9}$$

Non-schooling cognitive skills are equal to the total measure of cognitive skills minus the schooling cognitive skills measure.

[4]As mentioned in Ishikawa and Ryan (2002), this estimate is nevertheless not straightforward is one seeks to obtain a causal relationship because of an endogeneity problem. On the one hand, pursuing further schooling may be a screening process in which only those with higher abilities or skills move on to. On the other hand, those with a high level of abilities or skills may be discouraged to pursue further schooling due to the high wages they are offered, at their present level of schooling. The two-way relationship between cognitive skills and schooling could bias, either upwards or downwards, the estimate depending on the relative sizes of these counter-forces. Farber and Gibbons (1996) estimate schooling cognitive skills and non-schooling cognitive skills using an OLS estimate. The results of Charette and Meng (1998), in which instruments' exogeneity is debatable, suggest the impact of schooling on cognitive skills is underestimated in an OLS framework. Conversely the results of Glick and Sahn (2006), based on panel data, suggest the OLS and IV schooling estimates are consistent if not identical in magnitude when estimating cognitive skills.

$$NSCS_i = TCS_i - E(TCS_i|ST_i) = \nu \quad (10)$$

The years of schooling covariate is omitted from equations (9) and (10) and substituted by the schooling type dummies for two reasons. First, different curricula that require the same number of years of schooling may yield different cognitive skill proficiency. Second, using the number of years of schooling as a predictor of both schooling cognitive skills and wages would lead us to a perfect multicollinearity issue in equations (4) and (6).

One could evidently argue that employers can make use of skill tests during the hiring process to measure cognitive proficiency. Although this is true, employers presumably trust the schooling system better than a skill test. The serious works of Farber and Gibbons (1996), Altonji and Pierret (2001) and Lange (2007) all show that employers learn on initially unobserved cognitive skills.

3.4 The omitted variable bias - what can we expect?

The aim of this subsection is to show that our findings in the components of the return to schooling are neither mechanic nor random, but rely on the omitted variable bias properties. We give both a formal mathematical demonstration and a more intuitive graphical one as to why previous estimates of the components of the return to schooling are biased in virtually all cases.

Using the omitted variable formula, see Greene (2007), and the schooling and cognitive skill coefficients of equations (1), (2) and (4) we obtain the following equations[5]:

$$\begin{aligned} E\left[\alpha_1|\Omega\right] &= \beta_1 + \beta_2 \frac{Cov(S_i, TCS_i)}{Var(S_i)} + \sum_{i>2} \beta_i \frac{Cov\left(S_i, Z_i\right)}{Var\left(S_i\right)} \quad (11) \\ &= \beta_1 + \beta_2 \left(\frac{Cov(S_i, SCS_i)}{Var(S_i)} + \frac{Cov(S_i, NSCS_i)}{Var(S_i)} \right) + \phi \\ &= \beta_1 + \beta_2 \left[\xi + \mu\right] + \phi \end{aligned}$$

[5] As a reminder: α_1 is the Mincerian return to schooling and Ω the remaining control variables of equation (1). β_1 and β_2 are the returns to schooling noncognitive skills and total cognitive skills, equation (2). δ_1, δ_2 and δ_3 are the returns to schooling noncognitive skills, schooling cognitive skills and non-schooling cognitive skills, equation (6). Our variables of interest are β_1 and δ_1.

$$
\begin{aligned}
E\left[\alpha_1|\Omega\right] &= \delta_1 + \delta_2 \frac{Cov(S_i, SCS_i)}{Var(S_i)} + \delta_3 \frac{Cov(S_i, NSCS_i)}{Var(S_i)} + \sum_{i>3} \delta_i \frac{Cov\left(S_i, Z_i\right)}{Var\left(S_i\right)} \qquad (12) \\
&= \delta_1 + \delta_2 \xi + \delta_3 \mu + \psi
\end{aligned}
$$

We make three assumptions on the variables in equations (11) and (12).

- One, schooling and cognitive skills are non-negatively correlated as assumed by the human capital and signaling theories, consequently $Cov(S_i, SCS_i)/Var(S_i)$ (defined as ξ) is larger than or equal to zero.

- Two, years of schooling and non-schooling cognitive skills are uncorrelated, consequently $Cov(S_i, NSCS_i)/Var(S_i)$ (defined as μ) is nil. This assumption is nevertheless not straightforward to establish as four different people exist: (1) geniuses with high schooling and high non-schooling cognitive skills ($\mu > 0$), (2) nerds having high schooling cognitive skills, yet low non-schooling cognitive score ($\mu < 0$), (3) self made people with little schooling, yet high non-schooling cognitive skills ($\mu < 0$) and (4) people with low skills that have little schooling and also little non-schooling cognitive skills ($\mu > 0$). As shown in the appendix relaxing this assumption yields some non definite solutions. In the core of this paper we therefore prefer to restrain ourselves to the case where $\mu = 0$.

- Three, $\sum_{i>2} \beta_i \frac{Cov(S_i, Z_i)}{Var(S_i)}$ (defined as ϕ) is equal to $\sum_{i>3} \delta_i \frac{Cov(S_i, Z_i)}{Var(S_i)}$ (defined as ψ). Controlling for total cognitive skills or jointly for schooling cognitive skills and non-schooling cognitive skills does not influence the control variable coefficients (*e.g.* years of experience, country of birth...). Empirical evidence is given to assumptions one, two and three in the appendix. (A FAIRE).

Making use of the previous assumptions and because equations (11) and (12) are equal:

$$
\begin{aligned}
E\left[\alpha_1|\Omega\right] &= \beta_1 + \beta_2 \cdot \xi + \phi = \delta_1 + \delta_2 \cdot \xi + \delta_3 \cdot \mu + \psi \qquad (13) \\
&= \beta_1 + \beta_2 \cdot \xi = \delta_1 + \delta_2 \cdot \xi
\end{aligned}
$$

The return to total cognitive skills, β_2, is equal to the weighted return to schooling cognitive skills, δ_2, and to non-schooling cognitive skills, δ_3[6]. Depending on the different return to schooling cognitive skills and non-schooling cognitive skills five situations can occur. In a quest of clarity they are summed in table (1).

As one sees in table (1) the cognitive and noncognitive components of the return to schooling, measured in Gintis (1971) and Bowles *et al.* (2001), are truthful in just three cases (*i.e.* $\delta_1 = \beta_1$). In the first case, situation A, cognitive skills solely originate from schools and people have no non-schooling cognitive skills. Consequently $SCS = TCS$, $\delta_3 = 0$ and $\delta_2 = \beta_2$; therefore $\delta_1 = \beta_1$. In the second case, situation C, employers have perfect and immediate information on non-schooling cognitive skills therefore the return to schooling, non-schooling and total cognitive skills are identical. Consequently $\delta_2 = \delta_3 = \beta_2$ and $\delta_1 = \beta_1$. Finally, in situation E, schools yields no cognitive skills whatsoever. As cognitive skills are orthogonal to years of schooling the inclusion of the former does not affect the return to the latter. Consequently $NSCS = TCS$, $\delta_2 = 0$ and $\delta_3 = \beta_2$, leaving $\delta_1 = \beta_1$.

Situation B occurs when the return to schooling cognitive skills is larger than the return to non-schooling cognitive skills. This may occur when schooling has a positive signaling value and when employers learn on non-schooling skills. Were situation B to occur the noncognitive (cognitive) component of the return to schooling is overestimated (underestimated) when one simply controls for total cognitive skills. This happens because the effect of schooling cognitive skills on wages is underestimated due to the relatively lower return of non-schooling cognitive skills.

Situation D occurs when the return to non-schooling cognitive skills is larger than the return to non-schooling cognitive skills. This may arise if the schooling system is an inefficient place to acquire or signal cognitive skills and the labor market trusts non-schooling cognitive skills better than schooling cognitive skills. In this situation the noncognitive (cognitive) component of the return to schooling is underestimated (overestimated) when one controls for total cognitive skills. This takes place because the role of schooling cognitive skills is overestimated due to the relatively higher return of non-schooling cognitive skills.

In figure 2 the curve relates the relative mis-measurement of the components of the return to schooling for the different relative returns in schooling

[6] $\beta_2 = \gamma_2 \frac{SCS_i}{TCS_i} + \gamma_3 \frac{NSCS_i}{TCS_i}$, with $TCS_i = SCS_i + NSCS_i$ and SCS_i, $NSCS_i \geq 0$.

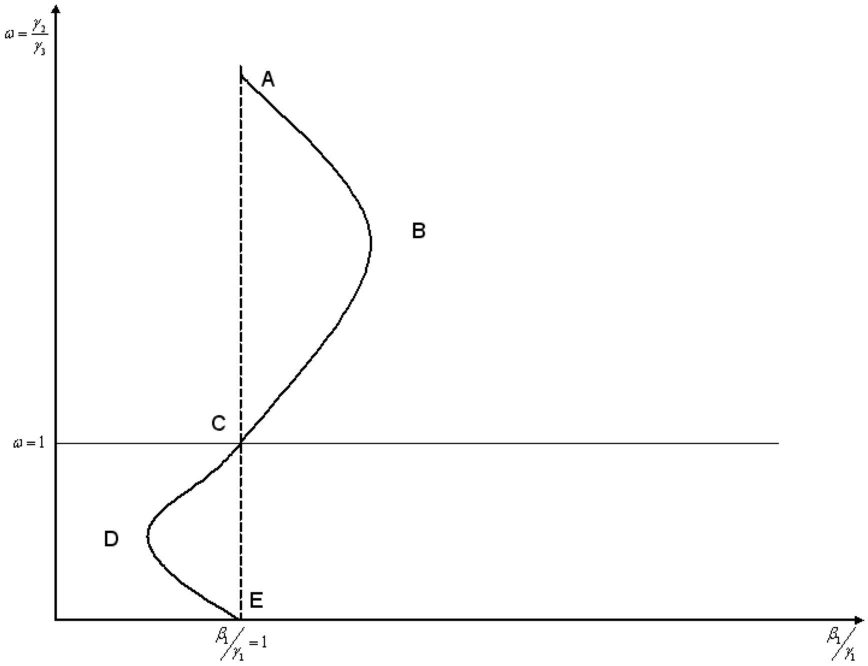

Figure 2: Graph relating the relative returns to skills and mismeaurements in schooling's components

cognitive skills over non-schooling cognitive skills. Situations above the continuous line represent cases where the return to schooling cognitive skills is larger than the return to non-schooling cognitive skills ($\gamma_2 > \gamma_3$); situations below the line represent reverse cases. To the left of the dashed line the noncognitive component of the return to schooling is underestimated according to the method used in Gintis (1971) and Bowles *et al.* (2001); to the right of the dashed line the noncognitive component of the return to schooling is overestimated.

Anticipating our results and making use of the findings of Farber and Gibbons (1996), Altonji and Pierret (2001) and Lange (2007) on the existence of employer learning, we favor situation B in which schooling cognitive skills are better rewarded than non-schooling cognitive skills yet with both returns positive. Consequently $\delta_2 > \delta_3 > 0$ and $\delta_1 < \beta_1$, suggesting the noncognitive component of the return to schooling has been overestimated in most of the previous literature.

4 Data

The Adult Literacy and Lifeskill Survey (ALL) is a cross-section international comparative survey designed to assess the literacy (prose and document), numeracy and problem solving skills of the adult population. The 2003 survey was conducted in the Bermudas, Canada, Italy, Norway, Switzerland, the United States and the Mexican state of Nuevo Leon. The initial Swiss[7] sample is constituted of 5'120 individuals. The data was collected in a two part, face-to-face, interview. The first part is a 45 minute nine theme questionnaire on the following subjects: schooling and citizenship; linguistic information; parental information; labor force information; literacy and numeracy; adult schooling and training; numeracy practices, information and communication technology literacy; and household information. The second phase is a written cognitive skill test. The test is graded on an objective and continuous scale. Questions reflect daily challenges individuals are confronted to.

The Swiss schooling system is somewhat similar to the one actually found in Germany with a highly developed vocational schooling system. Mandatory schooling is of nine years (primary and junior high school), after what individuals may pursue further schooling by undertaking a vocational or a

[7] Wage information for Canada, the United States and Nuevo Leon is not available in ALL. Amoung remaining countries, Switzerland has the largest usable sample of workers.

general track. Vocational education is accomplished in two stages. The first stage takes between three to four years, depending on the field, and yields a basic vocational training diploma. The second stage takes an additional four years and yields an advanced vocational training diploma. Vocational training consists of one to two days a week at a vocational school, with the remaining three to four days taking place on the job. Over half the people in our sample have undergone vocational training. As of general education, one needs to obtain a general culture or a high school diploma before going to applied science schools, colleges or universities. Cognitive skills acquired by vocational training are more job specific than ones acquired by general schooling.

All three cognitive skill measures are highly correlated; introducing them jointly yields inconsistent and nonsignificant results. The total cognitive skill measure used throughout this paper is the arithmetic average of prose, document and numeracy skills. Problem solving skills are omitted from the total cognitive skill measure, because an important share of the sample did not take this skill test[8].

The measure of innate "ability" is the result of a factor analysis on how the individuals enjoyed math in school, understood math classes, got good grades and if teachers went to fact. The possible answers were: strongly agree, agree, disagree and strongly disagree. Because answers are qualitative one cannot use a principal component analysis, but must use a polychoric factor analysis.

The final sample, restricted to individuals having worked without interruption during the 12 months preceding the interview, is constituted of 1'146 men and 984 women. For part-time workers (less than 40 hours a week) a full time (40 hours a week) standardized wage is computed.

The descriptive statistics in table 2 show men undergo more years of schooling and have a higher total cognitive skills score.

As predicted by the human capital and signaling theories schooling and cognitive skills are positively related, table 3. "For each domain, proficiency is denoted on a scale ranging from 0 to 500. Each score denotes a point at which a person has an 80 per cent chance of successfully completing tasks that are associated with similar levels of difficulty" OECD (2005). Five levels of difficulty were defined for prose, document literacy and numeracy.

[8] The correlation between the arihmetic average of the prose, document and numeracy skills, and a factor analysis of these skills is of 0.99.

Men and women who have not pursued their formal education further than mandatory schooling have a total cognitive skill score of 248 and 245. A score between 226-275 (level 2) requires people to locate single pieces of information in a text or document, or to understand basic mathematical concepts. Questions at this level consist of finding the number of countries in which the share of female teachers is smaller than 50 percent according to a chart, or to read a gas gauge and estimate the number of remaining liters of fuel. Men and women with a Ph.D. have a score of 319 and 306. A score between 276-325 (level 3) requires people to make links between the text and the questions, or to be capable to perform skills that require numbers and spatial sense. Questions at this level consist of describing, when using charts, the relationship between the sales of fireworks and the number of injuries. A score between 326-375 (level 4) requires people to make multiple feature matches in a text, or to be capable to understand a broad range of mathematical information. Questions at this level consist of determining the relative percentage changes in the amount of dioxin in breast milk across three measures.

Individuals having only accomplished high school have a total cognitive skill score of 250 points or eighty percent of the score of a person with a Ph.D. Such a result either indicates that primary schooling is the most productive educational degree in generating cognitive skills, or that a large share of the cognitive skills people possess are acquired outside the schooling system.

As stated by Ishikawa and Ryan (2002) and Green and Riddell (2003), cross-section data, such as the one we use, generally lack variables to instrument the potential endogeneity of the years of schooling variable. We therefore prefer not to use instruments rather than to force results out of bad ones. We resign ourselves to control for self-reported "ability" at age 15, but not to use this variable as an instrument.

5 Empirical estimates and results

Our findings show over half the return to schooling is constituted of cognitive skills, versus less than 10% using the method developed by Gintis (1971) and Bowles *et al.* (2001). Our signaling measure also shows that cognitive skills that originate from a schooling environment are several times more likely to be rewarded than those that do not originate from a schooling environment. Empirical estimates proceed in reverse order from the one established in the model section. We first separate cognitive skills *per* origin and then run wage equations.

5.1 Separating cognitive skills by sources

The results of regressing schooling variables and other variables observed by employers over total cognitive skills are displayed in table 4. Ten schooling dummy variables are included in the regression: general culture school (GCS), basic vocational training (BVT), high school (HS), teaching program (TP), advanced vocational training (AVT), applied science school (ASS), bachelor's degree (BAC), master's degree (MAS), Ph.D. and other. The base category is composed of people having not pursued further schooling than compulsory education.

As predicted by both the human capital and signaling theories table 4 shows there is a strong and significant correlation between cognitive skills and schooling diplomas. Yet schooling covariates explain a fifth of the variance in cognitive skills. This finding is consistent with previous research based both on children and adults: "Across almost all the specifications considered, we found that mother's accumulated ability, as measured by the AFQT, and home inputs (contemporaneous and lagged) are substantive determinants of children's test scores in math and reading." Todd and Wolpin (2007) and "The picture that emerges suggests a powerful role for environment in shaping individual IQ." Dickens and Flynn (2001). Controlling for schooling cognitive skills when quantifying the cognitive and noncognitive components of the return to schooling and not total cognitive skills is closer to reality because it accounts for what schooling truly yields and is not biased by out of school influences.

5.2 Wages, schooling's components and signaling

To compare both estimates of schooling's components and to obtain a signaling measure we run four regressions. Estimation I, equation (1), is the standard Mincerian wage equation. Estimation II, equation (2), additionally controls for total cognitive skills. The schooling coefficients of estimations I and II allow us to measure the components of the return to schooling according to Bowles *et al.* (2001). Estimation III, equation (4), controls for the same variables as estimation I as well as for schooling cognitive skills.

Comparing the schooling coefficients of estimations I and III yields the components of the return to schooling according to the method developed in this paper. Estimation IV, equation (6), additionally includes a measure of non-schooling cognitive skills. This allows us to compare the schooling cognitive skill coefficient with the non-schooling cognitive skill coefficient[9].

5.2.1 Male estimates

In estimation I an additional year of schooling increases wages by 8.0%. This return encompasses the return to both the cognitive and noncognitive skills an additional year of schooling yields. All things being equal, maximum wage is reached after 32 years of labor market experience. Similar results are found when using datasets representative of the full Swiss population.

Estimation II additionally controls for total cognitive skills. As predicted by Bowles *et al.* (2001) there is a small, yet statistically significant, drop in the years of schooling coefficient between estimations I and II. If one assumes all the cognitive skills people possess are acquired or signaled by schooling, the noncognitive curriculum of an additional year of schooling enhances wages by 6.9%. Consequently the cognitive skills related to an additional year of schooling only increase wages by a mere 1.1% (8.0%-6.9%).

Estimation III drops the assumption that all cognitive skills are acquired in school and controls for cognitive skills that originate from a schooling environment. The years of schooling coefficient is now a mere 3.9, half its initial value. The schooling cognitive skill coefficient is considerably larger than the total cognitive skill coefficient. This is because schooling cognitive skills are better rewarded, due to signaling, than similar non-schooling cognitive skills.

Table 6 reports the cognitive and noncognitive components of the return to schooling, measured using both the "classical" method and the one developed in this paper.

According to the "classical" model, 87.0% (=0.067/0.077) of what the labor market praises in schooling is its noncognitive component. Bowles *et al.* (2001) find similar results for the US. If one believes this, schools are a place where people acquire noncognitive skills or are sorted on a noncognitive

[9] Robustness checks were conducted for all four estimations by including both separately and jointly a blue-white collar dummy, nine activity dummies and fifteen industry dummies. Schooling and skill coefficients remain significant but are smaller in size. The conclusions and learnings of this paper remain similar whether collar-color, activity and industry dummies are included or not.

skill criterion. Such an important noncognitive component also suggests that using cognitive skill tests such as PISA, PIRLS or TIMSS to measure schooling quality is largely erroneous, because cognitive skills represent less than 15% of the private return to schooling. Our results show schooling is central in determining wages and extra schooling must be matched with additional cognitive skills to be truly profitable as 50% of the return to schooling is cognitive. An additional year of schooling, with no change in cognitive skills, increases wages by 4.0%. This same year of schooling with an increase in cognitive skills yields a wage increase of 8.0%. Because we lack information on the acquisition cost of cognitive and noncognitive skills we can not infer on their respective profitability.

The inclusion of non-schooling cognitive skills in estimation IV has very little effect on the years of schooling and schooling cognitive skill coefficients. When comparing both cognitive skill coefficients one sees that schooling cognitive skills are three times more likely to be rewarded on average than non-schooling cognitive skills (0.181/0.063). Cognitive skills identical in nature, but that originate from different areas are rewarded at totally different rates[10].

5.2.2 Female estimates

Results on female wage estimations are always subject to selectivity bias and years of experience mis-measurement. Despite these caveats the comments expressed for men remain globally valid for women and confirm our results on schooling's components. The years of schooling coefficient drops, when we include a measure of total cognitive skills, by less than 10%. The drop is of 56%, when we control for schooling cognitive skills, suggesting more than half the return to schooling is noncognitive.

The cognitive component of the return to schooling, table 8, is considerably higher than what is found when using the "classical" method. Results show more than half of what the labor market rewards in schooling is cognitive.

[10] Unreported estimates show the interaction term between non-schooling cognitive skills and years of experience is positive and statistically significant. Reversely the interaction between schooling cognitive skills and years of experience is negative and statistically significant. This suggests learning takes place on the labor market.

5.2.3 Multicollinearity measures

A potential drawback when one controls for years of schooling, schooling cognitive skills and total cognitive skills is whether the variables are multicollinear. To be on the safe side we measure the variance inflation factors (VIF) in all four estimations. A measure of VIF involves examining the R^2 from regressing each independent variable against all the others. The rule of the thumb, see Chatterjee and Hadi (2006), when suggests that the VIF value for each variable should remain below 10. In absence of any linear relation between the independent variable, the VIF is equal to one.

Estimations I and II are canonical wage estimate and their mean VIF is of 3.7, the mean VIF of estimation III and IV is within the same range. The inclusion of the schooling cognitive skill and non-schooling cognitive skill variables does not load the model with multicollinearity. The VIF of years of schooling and schooling cognitive skills remains well below the critical threshold of 10.

6 Conclusion

This paper provides theoretical proof that previous measures of the components of the return to schooling were generally biased; empirical estimates show that the return to schooling is composed both of cognitive skills (*e.g.* the capacity to process information and apply knowledge) and noncognitive skills (*e.g.* behavioral and personality traits) in equal shares. Our results consequently challenge previous research, such as Gintis (1971) and Bowles *et al.* (2001), that suggest 90% of the return to schooling is noncognitive. Said differently our estimates ensure the capacity to process information and apply knowledge, that originates from schooling, is largely rewarded by the labor market. Reversely data leaves less space to personality traits such as self-esteem and perseverance. Measures also show that cognitive skills acquired or signaled via schooling diplomas are several times more likely to be rewarded than similar cognitive skills acquired elsewhere.

These findings are obtained by splitting the total cognitive skill measure available in the data between schooling and non-schooling ones. This leaves place for a distinction between people with high cognitive skills in both schooling and non-schooling environments; from those with high schooling cognitive skills, but little non-schooling cognitive skills; from those with little schooling cognitive skills yet high non-schooling cognitive skills; from those with poor schooling and non-schooling cognitive skills.

According to the method developed in this paper half of what the labor market rewards in schooling is noncognitive, or cognitive skills not accounted for in the data. The skill measure used in this paper is one of basic cognitive skills, suggesting the cognitive component of the return to schooling measured here may be a lower bound. Advanced cognitive skills, largely job dependent, such as rapid matrix flipping for econometricians or neat snipping for barbers are bound to increase the cognitive component of the return to schooling upwards.

Our findings have direct policy implications as they both validate the use of cognitive skill tests as a measure of schooling quality and promote cognitive skills to take a consequent share of schooling curricula. As a result policies seeking to use cognitive skill tests as schooling quality measures (*e.g.* PISA, TIMMS and PIRLS) and to increase the cognitive quality of formal education are appropriate.

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Table 1: Differences in the returns to cognitive skills

Situation				SCS	NSCS
A	$\delta_2 > 0$ and $\delta_3 = 0$	$\delta_2 = \beta_2$	$\delta_1 = \beta_1$	>0	=0
B	$\delta_2 > \delta_3 \geqslant 0$	$\delta_2 > \beta_2$	$\delta_1 < \beta_1$	>0	>0
C	$\delta_2 = \delta_3$	$\delta_2 = \beta_2$	$\delta_1 = \beta_1$	>0	>0
D	$\delta_3 > \delta_2 \geqslant 0$	$\delta_2 < \beta_2$	$\delta_1 > \beta_1$	>0	>0
E*	$\delta_3 > 0$ and $\delta_2 = 0$	$\delta_2 < \beta_2$	$\delta_1 = \beta_1$	=0	>0

* E requires cognitive skills to be unrelated to schooling ($\xi = 0$).

Table 2: Sample descriptive characteristics

	Male	Female
Years of schooling	14.56	13.78
	(3.28)	(3.30)
Total cognitive skills	290.21	282.19
	(37.42)	(34.34)
Years of potential experience	21.46	21.55
	(11.43)	(11.44)
"Ability" at age 15$^{\#}$	0.00	0.00
	(1.00)	(1.00)
French speaking^{+}	0.29	0.36
	(0.46)	(0.48)
Italian speaking^{+}	0.25	0.22
	(0.44)	(0.42)
German speaking^{+}	0.46	0.42
	(0.50)	(0.49)
Born in Switzerland^{+}	0.82	0.81
	(0.39)	(0.39)
Father born in Switzerland^{+}	0.71	0.69
	(0.45)	(0.46)
Mother born in Switzerland^{+}	0.69	0.66
	(0.46)	(0.48)
Father university degree^{+}	0.22	0.22
	(0.41)	(0.41)
Mother university degree^{+}	0.06	0.07
	(0.24)	(0.26)
Sample size	1'146	984

Robust standard deviations in parentheses.
$^{\#}$ standardized measure. $^{+}$dummy variables expressed as a sample percentage. Non-weighted.

Table 3: Years of schooling and and total cognitive skills per schooling type

	Male		Female	
	S	TCS	S	TCS
Junior high school	10.0	253.7	9.6	252.4
General culture school	12.3	284.7	12.3	268.1
Basic vocational training	12.8	276.1	12.2	274.4
High school	13.8	294.1	14.4	288.5
Teaching program	15.7	301.6	14.5	297.1
Advanced vocational training	14.8	299.3	14.7	292.7
Advanced science school	16.2	310.0	15.5	285.6
Bachelor	17.2	305.4	16.9	289.1
Master	18.4	311.3	18.4	305.4
Ph.D.	20.8	318.9	21.1	307.6
Other	14.9	272.9	14.2	288.7

S=years of schooling and TCS=Total cognitive skills. Non-weighted.

Table 4: Total cognitive skills, OLS regression

	Male	Female
General culture school+	30.99	15.63
	(10.52)	(6.01)
Basic vocational training+	22.41	21.98
	(4.94)	(3.82)
High school+	40.40	36.04
	(7.29)	(5.22)
Teaching program+	47.85	44.60
	(8.26)	(5.16)
Advanced vocational training+	45.60	40.18
	(5.11)	(4.61)
Applied science school+	56.24	33.17
	(6.13)	(8.17)
Bachelor+	51.69	36.58
	(7.70)	(7.43)
Master+	57.61	52.97
	(5.38)	(4.35)
Ph.D.+	65.12	55.12
	(5.78)	(7.90)
Other+	19.16	36.21
	(12.11)	(9.32)
Constant	253.73	252.47
	(4.68)	(3.52)
Adjusted R^2	0.2078	0.1817
Number of observations	1’146	984

Base category is junior high school.

Robust standard errors in parentheses. +dummy variables.

Table 5: Log annual earnings, OLS regressions, male

	I	II	III	IV
Years of schooling	0.077	0.067	0.039	0.038
	(0.01)	(0.01)	(0.01)	(0.01)
TCS#		0.105		
		(0.01)		
SCS#			0.174	0.181
			(0.03)	(0.02)
NSCS#				0.063
				(0.01)
Experience/10	0.677	0.671	0.607	0.614
	(0.06)	(0.06)	(0.06)	(0.06)
$(\text{Experience}/10)^2$	-0.106	-0.102	-0.095	-0.093
	(0.01)	(0.01)	(0.01)	(0.01)
Constant	9.303	9.483	9.942	9.960
	(0.13)	(0.13)	(0.14)	(0.14)
Adjusted R^2	0.3836	0.4075	0.4223	0.4327
Sample size		1'146		

Robust standard errors in parentheses. # standardized variables. Additional control dummy variables are place of birth, location of residence, father born in Switzerland, mother born in Switzerland, father university degree, mother university degree and "ability". TCS=Full cog. skills, SCS=Schooling cog. skills and NSCS= Non-schooling cog. skills.

Table 6: Schooling coefficients and components, male

Components	τ	υ	$\tau^{'}$	$\upsilon^{'}$
	87.0%	13.0%	50.9%	49.1%

τ and υ are the noncognitive and cognitive components of the return to schooling. τ=II/I, $\nu = 1 - \tau$, $\tau^{'}$=III/I and $\nu^{'} = 1 - \tau^{'}$.

Table 7: Log annual earnings, OLS regressions, female

	I	II	III	IV
Years of schooling	0.071	0.064	0.031	0.030
	(0.01)	(0.01)	(0.01)	(0.01)
TCS#		0.074		
		(0.02)		
SCS#			0.177	0.184
			(0.02)	(0.02)
NSCS#				0.044
				(0.02)
Experience/10	0.473	0.475	0.420	0.424
	(0.07)	(0.06)	(0.06)	(0.06)
$(\text{Experience}/10)^2$	-0.078	-0.075	-0.070	-0.066
	(0.01)	(0.01)	(0.01)	(0.01)
Constant	9.429	9.535	10.083	10.109
	(0.12)	(0.12)	(0.12)	(0.12)
Adjusted R^2	0.2517	0.2652	0.3017	0.3063
Sample size	984			

Robust standard errors in parentheses. # standardized variables. Additional control dummy variables are place of birth, location of residence, father born in Switzerland, mother born in Switzerland, father university degree and mother university degree. TCS=Full cog. skills, SCS=Schooling cog. skills and NSCS=Non-schooling cog. skills.

Table 8: Schooling coefficients and components, female

Components	τ	υ	τ'	υ'
	90.1%	9.9%	43.7%	56.3%

τ and υ are the noncognitive and cognitive components of the return to schooling. τ=II/I, $\nu = 1 - \tau$, τ'=III/I and $\nu' = 1 - \tau'$.

Table 9: Variance inflator factors, VIF

	Male				Female			
Estimation	I	II	III	IV	I	II	III	IV
Years of schooling	1.2	1.3	2.4	2.4	1.3	1.4	2.6	2.6
Experience	14.2	14.3	14.8	14.8	14.0	14.0	14.3	14.3
Experience^2	14.4	14.5	14.7	14.7	14.0	14.0	14.2	14.3
TCS	-	1.4	-	-	-	1.5	-	-
SCS	-	-	2.4	2.4	-	-	2.5	2.5
NSCS	-	-	-	1.2	-	-	-	1.2
Mean VIF	3.8	3.7	3.9	3.7	3.8	3.6	3.8	3.6

TCS=Total Cognitive Skills and SCS=Schooling Cognitive Skills NSCS= Non-Schooling Cognitive Skill. Other variables not reported.