A New Measure of the Cognitive and Noncognitive Components of the Return to Schooling

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August 31, 2007

Abstract

What is it about schooling that the labor market rewards? This paper shows that when specifically controlling for schooling cognitive skills (*e.g.* the capacity to process information and apply knowledge) and not cognitive skills as a whole, close to 70% of the return to schooling is cognitive. This contrasts with the previous literature that strongly favored noncognitive hypothesis (*e.g.* behavioral, personality and physical traits). If one believes such results schools are a place where one acquires or is sorted on a knowledge criterion and not a behavioral one. Findings also suggest that cognitive skills acquired in school are more likely to be rewarded than their non-schooling counterpart, this is due to signaling.

JEL classification: I21; J24; J31

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

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I thank Sandra Black, Jean-Marc Falter, Yves Flückiger, David Green, Daniel Pasche, Mathias Thoenig and Patrick Werquin for very useful comments. Financial support from the "Leading House on the Economics of Education" is gratefully acknowledged.

1 Introduction

Both the human capital and signaling theories hypothesize schooling and skills are positively related, yet 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, is acquired or signaled by schooling.

Cognitive skills are defined as the capacity to process information and apply knowledge. Intelligence Quotient tests and the Air Force Qualification Test are adequate tools to asses cognitive skill proficiency. Reversely, noncognitive skills relate to behavioral, personality and physical traits. Creativity, perserverance, dependability, consistency, risk-aversion, self-esteem, beauty and leadership skills are examples of noncognitive skills.

With the notable exception of Gintis (1971) and Bowles *et al.* (2001) little research has sought to discover what triggers the educational earning premium. Their findings suggest over 80% of the return to schooling is noncognitive, leaving less than 20% to be cognitive. Such results establish schools are a place one acquires or is sorted on a behavioral criterion (*i.e.* noncognitive skills) and not an intellectual one (*i.e.* cognitive skills).

With respect for the literature on schooling, cognitive skills, noncognitive skills and wages this paper yields two contributions. First, by developing a simple model relating years of schooling, schooling cognitive skills, schooling noncognitive skills and non-schooling cognitive skills we find that up to 70% of the return to schooling is cognitive. This contrasts with the previous literature that strongly favored noncognitive skills. Second, by comparing the schooling cognitive skill coefficient with the non-schooling cognitive skill coefficient we develop a signaling measure. Data shows that cognitive skills acquired in school are several times more likely to be rewarded than their non-schooling counterpart.

The approach differs from previous methods used to quantify schooling's components by specifically controlling for schooling cognitive skills (*e.g.* cognitive skills anticipated by employers on the basis of observable characteristics) and not all the cognitive skills a person has. This allows us to distinguish people that are highly skilled both in 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.

Not only do cognitive skills represent an important share of the return to schooling, but obtaining or signaling such skills by educational diplomas is considerably more profitable than without. Including a cognitive skill measure in a schooling quality index and emphasizing the cognitive curricula of formal education seem to be appropriate policies.

The paper unfolds as follows. Section 2 summarizes the literature and previous empirical results. Section 3 presents the model. Section 4 describes the data. Section 5 displays results. Finally, section 6 concludes.

2 Literature review

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. An extensive literature review can be found in Bowles *et al.* (2001).

2.1 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 the regression of the total cognitive skills measure 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. Econometric properties ensure us that non-schooling cognitive skills are orthogonal to variables observed 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. To do so they regress the total cognitive measure over the number of years of schooling and schooling type dummies (*e.g.* primary school or high school)[1]. The result of their first step is that between 30% and 50% of people's cognitive skills are acquired or signaled through formal education. In the second step they estimate wages when controlling for schooling type, schooling and non-schooling cognitive skills.

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

When assessing the cognitive and noncognitive components of the return to schooling Bowles *et al.* (2001) make two assumptions. First, they assume schooling contributes to wages by other means than simply cognitive skills (*i.e.* noncognitive skills). Second, by the way they measure the components of the return to schooling, they assume cognitive skills are exclusively acquired or signaled by schooling. This means there is no way for people to acquire skills outside the schooling system.

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%. Thus they conclude 82% of what the labor market rewards in schooling is noncognitive.

3 Model

This section develops the empirical model, splits cognitive skills into a schooling part and a non-schooling part, presents a measure of schooling's components, suggests a signaling measure using cognitive skill coefficients and demonstrates why previous estimates of the noncognitive component of the return to schooling are upwards biased.

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

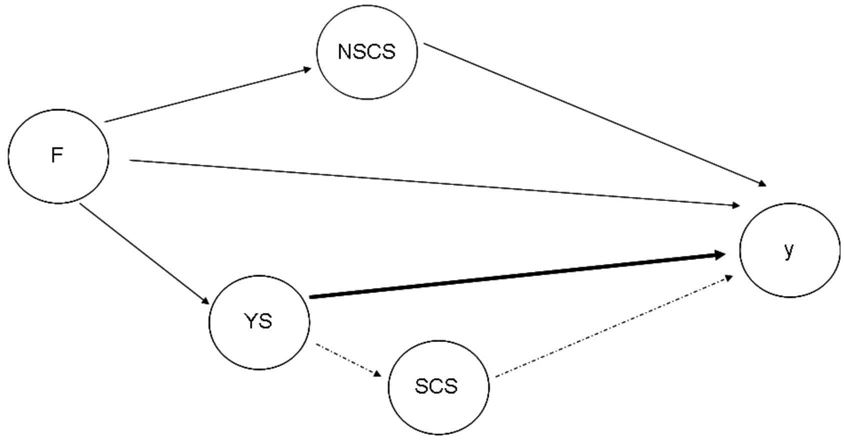

Figure 1: Model relating schooling, skills and wages

3.1 Empirical framework 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. y is wages, YS is years of schooling, SCS is schooling cognitive skills, $NSCS$ is non-schooling cognitive skills and F is family background. We assume all relations between the variables in figure 1 are positive. The bold arrow represents the noncognitive return to schooling. The dotted arrows represent the cognitive return to schooling. Although variables such as innate ability and non-schooling noncognitive skills (*e.g.* beauty and height) also influence wages, we omit them from the model because they are not available in our data.

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

$$y_i = \alpha_0 + \alpha_1 YS_i + \alpha_2 X_i + \alpha_3 F_i + \varepsilon \quad (1)$$

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.

Wage estimates controlling for cognitive skills are formulated as follows:

$$y_i = \beta_0 + \beta_1 YS_i + \beta_2 TCS_i + \beta_3 X_i + \beta_4 F_i + \varepsilon \quad (2)$$

β_2 is the return to full cognitive skills. Total cognitive skills, TCS, measures all the cognitive skills an individual possess, without distinction between where they were acquired. Were the assumption that all cognitive skills are acquired or signaled by schooling to hold, β_1 would be the noncognitive return to schooling (the cognitive return to schooling is captured by β_2).

Following the line of 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. 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 ($\alpha_1 = \beta_1$).

The measure of TCS is observed by the researcher but only partially by employers. Consequently only what is observed by the employer can be attributed to schooling. The interest in equation (4) lies in the fact that it accounts for the information gap between researchers and employers:

$$y_i = \gamma_0 + \gamma_1 YS_i + \gamma_2 SCS_i + \gamma_3 X_i + \gamma_4 F_i + \varepsilon \tag{4}$$

Therefore γ_1, the years of schooling coefficient, becomes is the true measure of the noncognitive return to schooling. The cognitive component of schooling is captured by γ_2. SCS is the expected cognitive skill score *per* individual based on his schooling curricula, place of birth, location of residence and age[2].

The noncognitive and cognitive components of the return to schooling, when specifically controlling for schooling cognitive skills (and not cognitive skills as a whole), are approximated as follows:

[2]Place of birth, location of residence and age variables are included to control for the difference in schooling quality between and within countries, see OECD (2005), and age-related cognitive decline, see O'Sullivan *et al.* (2001).

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

The specification of equations (2) and (4) 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 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 educational or professional origin.

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

$$y_i = \delta_0 + \delta_1 YS_i + \delta_2 SCS_i + \delta_3 NSCS_i + \delta_4 X_i + \delta_5 F_i + \varepsilon \tag{6}$$

The interest in equation (6) lies in the comparison of the schooling cognitive skill coefficient with the non-schooling cognitive skill coefficient, thus leading to a signaling measure. Schooling cognitive skills and non-schooling cognitive skills are both identical in nature as they originate from the 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 of these skills, but as a disparity in the odds of them being observed and consequently rewarded by the labor market.

The following ratio informs us on the odds schooling cognitive skills have in being rewarded over non-schooling cognitive skills:

$$\omega = \frac{\delta_2}{\delta_3} \tag{7}$$

ω is assumed to be larger than 1 because information is never free. Schooling cognitive skills, δ_2, are immediately rewarded as they are immediately observed by employers. Assuming employers learn, non-schooling cognitive skills will gradually be rewarded by the labor market, see Farber and Gibbons (1996).

3.2 Schooling cognitive skills and non-schooling cognitive skills

The challenge when estimating equation (4) is that the schooling cognitive skill measure is not available in the data and needs to be estimated using the total cognitive skill measure and variables observed by employers. To obtain a measure of schooling cognitive skills, SCS, we follow the footsteps of Farber and Gibbons (1996) and Ishikawa and Ryan (2002):

$$TCS_i = \theta_0 + \theta_1 YS_i + \theta_2 ST_i + \theta_3 Z_i + \varepsilon \tag{8}$$

The total cognitive skill measure, TCS, is split between those acquired in school and those acquired outside of school. Using the number of years of schooling, YS, as well as schooling type dummies, ST, (*e.g.* high school diploma or bachelor's degree) allows us to control for the quantitative and qualitative effects of schooling on cognitive skills. A control vector Z is included for age, place of birth and location of residence[3].

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

Using the significant coefficients of equation (8) we obtain a measure of schooling cognitive skills. Non-schooling cognitive skills are equal to the total measure of cognitive skills minus the schooling cognitive skills measure.

$$NSCS_i = TCS_i - E(TCS_i | YS_i, ST_i, Z_i) \tag{10}$$

[3] As mentioned in Ishikawa and Ryan (2002), this estimate is nevertheless not straightforward 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 counterforces. 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.

3.3 Omitted variable bias

With basic assumptions we show the noncognitive component of the return to schooling τ, equation (3), is biased upwards. Using the omitted variable formula, see Greene (2002), and the schooling and cognitive skill coefficients of equations (1), (2) and (4) we obtain the following equations:

$$
\begin{aligned}
E\left[\alpha_1|\Omega\right] &= \beta_1+\beta_2\left(\frac{\sum anedu_i\cdot FCS_i}{\sum anedu_i^2}\right) && (11)\\
&= \beta_1+\beta_2\left[\left(\frac{\sum anedu_i\cdot SCS_i}{\sum anedu_i^2}\right)+\left(\frac{\sum anedu_i\cdot NSCS_i}{\sum anedu_i^2}\right)\right]\\
E\left[\alpha_1|\Omega\right] &= \gamma_1+\gamma_2\left(\frac{\sum anedu_i\cdot SCS_i}{\sum anedu_i^2}\right) && (12)
\end{aligned}
$$

α_1 is the full 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). γ_1 and γ_2 are the returns to schooling noncognitive skills and schooling cognitive skills, equation (4). Our variables of interest are β_1 and γ_1.

We make three assumptions on the variables in equations (11) and (12). First, because schooling cognitive skills are easier for employees to signal than total cognitive skills the odds of them being rewarded is higher, consequently γ_2 is larger than β_2. Second, $\sum anedu_i\cdot SCS_i$ (hereafter ξ), is positive because as assumed by both the human capital and signaling theories, schooling cognitive skills are positively related with the number of years of schooling. That is, the higher number of years of schooling of those with a positive (high) schooling cognitive skill score positively outweigh the low (negative) cognitive skill score of those with a smaller number of years of schooling. Third, $\sum anedu_i\cdot NSCS_i$ (hereafter μ), is approximately equal to zero, because non-schooling cognitive skills are orthogonal to all variables observed by the labor market upon employment, see Farber and Gibbons (1996).

As equations (11) and (12) are equal:

$$E\left[\alpha_1|\Omega\right]=\beta_1+\beta_2\cdot\xi+\beta_2\cdot\mu=\gamma_1+\gamma_2\cdot\xi$$

$$\beta_1-\gamma_1=(\gamma_2-\beta_2)\cdot\xi-\beta_2\cdot\mu\simeq(\gamma_2-\beta_2)\cdot\xi>0$$

Because $\gamma_2 > \beta_2$, $\xi > 0$ and $\mu \simeq 0$, the noncognitive return to schooling, β_1, is larger than the noncognitive return to schooling, γ_1. The consequence being that the noncognitive component of the return to schooling measured in Gintis (1971) and Bowles *et al.* (2001) is biased upwards.

Empirical support for assumption 1 is found in columns II and III of tables 5 and 7. Empirical support for assumptions 2 and 3 are displayed in table 9.

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[4] 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 from 0 to 500. Questions reflect daily challenges individuals are confronted to.

The Swiss schooling system is somewhat similar to the one actually found in the United States: mandatory schooling is of nine years (primary and junior high school), after what individuals may pursue further schooling by undertaking a general or a vocational curricula. Vocational education in Switzerland 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. 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.

[4] 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.

Over half the people in our sample a undergone vocational training.

The final sample, restricted to individuals having worked without interruption during the 12 months preceding the interview, is constituted of 1'185 men and 1'013 women[5]. For part-time workers (less than 40 hours a week) a full time (40 hours a week) standardized wage is computed. The dependent variable is the natural logarithm of the annual standardized wage. This choice lies on the better empirical results of using annual wages as the dependent variable, versus weekly or hourly wages, see Card (1999).

The total cognitive skill measure is the arithmetic average of prose, document and numeracy skills. Problem solving skills are omitted from the total cognitive skill measure, because a significant share of the sample did not take the test. All three cognitive skills are highly correlated, introducing them jointly yields inconsistent and nonsignificant results.

The descriptive statistics in table 1 show men undergo more years of schooling and perhaps consequently have a higher total cognitive skills score.

[5] 1'266 individuals had been unemployed or inactive during the 12 months proceeding the interview; 1'098 could not establish the number of hours they worked or had not worked with the same employer during the 12 months proceeding the interview; 462 could not establish their wage; finally 96 could not establish the number of years of schooling they undertaken or reported contradictory responses between the number of years of schooling and the type of schooling degree (*e.g.* obtaining a bachelor's degree with only 2 years of schooling).

Table 1: Descriptive statistics

	Male	Female
Years of schooling	14.45	13.69
	(3.39)	(3.49)
Total cognitive skills	289.27	281.07
	(37.97)	(35.81)
Years of potential experience	21.71	21.77
	(11.52)	(11.57)
French speaking^{+}	0.29	0.36
	(0.46)	(0.48)
Italian speaking^{+}	0.25	0.23
	(0.44)	(0.48)
Born in Switzerland^{+}	0.81	0.80
	(0.39)	(0.40)
Father born in Switzerland^{+}	0.70	0.69
	(0.46)	(0.47)
Mother born in Switzerland^{+}	0.68	0.65
	(0.47)	(0.48)
Father university degree^{+}	0.22	0.22
	(0.41)	(0.41)
Mother university degree^{+}	0.06	0.07
	(0.24)	(0.25)
Sample size	1'185	1'013

Robust standard deviation in parentheses. $^{+}$dummy variables.

As predicted by both the human capital and signaling theories schooling and cognitive skills are positively related, table 2. 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 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 gallons of fuel. Men and women with a Ph.D. have a score of 319 and 306. A score between 276-325 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 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.

Table 2: Schooling types and total cognitive skills, descriptive statistics

	Male			Female		
	Mean	Std. dev.	N	Mean	Std. dev.	N
Primary	222.83	27.09	13	199.39	21.01	10
Junior High	253.44	36.45	62	251.25	34.28	92
GCS	286.32	40.39	19	268.11	29.49	36
BVT	275.92	33.57	472	274.40	30.08	406
HS	293.95	41.76	59	288.98	36.25	89
TP	302.70	34.32	26	297.30	29.30	64
AVT	298.95	29.46	207	292.65	31.15	110
ASS	310.36	34.39	76	285.64	38.83	27
BAC	305.42	35.51	33	290.91	33.19	25
MAS	311.71	31.61	149	305.06	27.56	113
Ph.D.	318.85	25.21	55	307.60	38.52	29
Undefined	269.90	38.44	14	270.23	45.51	12
Full sample	289.29	37.97	1'185	281.07	35.81	1'013

Robust standard deviations. GCS=General Culture School, BVT=Basic Vocational Training, HS=High School, TP=Teacher Program, AVT=Advanced Voc. Training, ASS=Applied Science School, BAC=Bachelor, MAS= Master and N=Number of obs.

Individuals with primary education have a total cognitive skill score of 210 points: two-thirds 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. This latter argument seems far more realistic (individuals with no schooling have a score of 191 points, individuals having not completed primary schooling have 210 points).

As stated by Ishikawa and Ryan (2002) and Green and Riddell (2003), cross-section data 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. Valid instruments, as well as econometric methods, do exist to control for the endogeneity of the years of schooling variable and the causality between schooling and skills, Black *et al.* (2005) and (2007) and Heckman *et al.* (2006), but these approaches rely on unique panel data.

5 Empirical estimates and results

Our findings suggest close to 70% of the return to schooling is constituted of cognitive skills, versus less than 10% using the classical method. Our signaling measure also shows that cognitive skills that originate from a schooling environment are nearly ten times more likely to be rewarded than those that do not originate from a schooling environment. Our empirical estimates proceed in reverse order from the one established in the model section. We start by splitting the cognitive skill measure and only after do we run wage equations.

5.1 Separating cognitive skills by sources

Prior to estimating wages, the total cognitive skill measure has to be split into its schooling and non-schooling parts. The results of regressing schooling variables and other variables observed by employers over total cognitive skills are displayed in table 3. Nine 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) and Ph.D. The omitted category (Other) is made of people having not pursued further schooling than compulsory education. Using a continuous measure of the number of years of schooling and dummy variables for different schooling types allows us to measure the qualitative and quantitative impact of schooling on cognitive skills. Variables for place of birth, location of residence and age are also included. They attempt to control for schooling quality differences between and within countries, OECD (2005), vintage effects, Neuman and Weiss (1995), and neurological depreciation effects on cognitive skills, O'Sullivan *et al.* (2001).

Table 3: Total cognitive skills, OLS regression

	Male	Female
Years of schooling	1.35	2.10
	(0.43)	(0.44)
General culture school+	24.03	9.97
	(9.20)	(5.59)
Basic vocational training+	14.36	12.67
	(4.02)	(3.82)
High school+	33.06	26.79
	(6.09)	(5.19)
Teaching program+	35.71	31.98
	(7.69)	(5.32)
Advanced vocational training+	33.58	26.72
	(4.60)	(4.78)
Applied science school+	41.18	18.63
	(5.73)	(7.90)
Bachelor+	42.75	22.55
	(7.42)	(7.50)
Master+	45.57	35.58
	(5.67)	(5.67)
Ph.D.+	48.91	37.28
	(6.84)	(9.15)
Age	-0.62	-0.66
	(0.08)	(0.09)
Born in Switzerland+	23.18	19.93
	(2.71)	(2.65)
French speaking	-7.88	-6.57
	(2.15)	(2.23)
Italian speaking	-12.99	-13.63
	(2.19)	(2.27)
Constant	256.47	250.23
	(6.84)	(7.98)
Adjusted R^2	0.3604	0.3371
Number of observations	1’185	1’013

Robust standard errors in parentheses. +dummy variables.
Omitted outcome: Some compulsory schooling (primary, junior high or undefined) and German speaking.

Table 4: Schooling cognitive skills per school type

	Male			Female		
Schooling type	SCS	TCS	SCS/TCS	SCS	TCS	SCS/TCS
GCS	45.23	286.32	15.8%	36.00	268.11	13.4%
BVT	36.12	275.92	13.1%	38.47	274.40	14.0%
HS	56.38	293.95	19.2%	57.24	288.98	19.8%
TP	61.42	302.70	20.3%	62.59	297.30	21.1%
AVT	58.12	298.95	19.4%	57.66	292.65	19.7%
ASS	67.56	310.36	21.8%	51.35	285.64	18.0%
BAC	70.61	305.42	23.1%	58.04	290.91	20.0%
MAS	75.07	311.71	24.1%	74.20	305.06	24.3%
Ph.D.	81.55	318.85	25.6%	81.73	307.60	26.6%

SCS=schooling cognitive skills and TCS=Total cognitive skills. SCS is estimated with equation (9) and significant coefficients of table (3). GCS=General Culture School, BVT=Basic Vocational Training, HS=High School, TP=teacher Program, AVT=Advanced Vocational Training, ASS=Applied Science School, BAC=Bachelor and MAS=Master. Age is set to 30 and place of birth is Switzerland.

The positive schooling coefficients indicate there is not only a quantitative effect of schooling on cognitive skills, but also a qualitative one, see table 3. Place of birth and location of residence dummy variables show their is a between and within country difference in the cognitive level of individuals. Age has a negative effect on the cognitive skill score, this may be due to vintage effects and neurological depreciation.

Schooling cognitive skills are reported in table 4 using the significant coefficients from table 3. The schooling cognitive skill score for a 30 year old Swiss born male with a General Culture School diploma is of 49.3 (=1.35*12.3+24.03-0.62*30+23.18), for the same person with a Ph.D. it is of 86.3 (=1.35*20.8+48.91-0.62*30+23.18). For males with a General Culture School diploma, only 15.8% of their cognitive skills are acquired or signaled by schooling. Reversely 84.2% of their cognitive skills are non-schooling cognitive skills. Basic vocational training and high school curricula take approximately the same number of years to accomplish, yet the schooling cognitive skill premium of a high school diploma over a basic vocational training diploma is of 50%. Results show the contribution of formal education in generating cognitive skills is relatively small at low levels of schooling and becomes more important at higher levels. Ishikawa and Ryan (2002) find the same trend. More importantly, table 4 shows the role of schooling in generating cognitive skills is far from being exclusive. Controlling for schooling cognitive skills when attempting to quantify 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 what employers anticipate based on what they observe.

5.2 Wages and schooling's components

To compare the two measures 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.

5.2.1 Males

Table 5: Log annual earnings, OLS regressions, male

	I	II	III	IV
Years of schooling	0.076	0.065	0.032	0.032
	(0.01)	(0.01)	(0.01)	(0.01)
TCS#		0.112		
		(0.01)		
SCS#			0.261	0.263
			(0.03)	(0.03)
NSCS#				0.064
				(0.01)
Experience/10	0.651	0.645	0.666	0.659
	(0.06)	(0.06)	(0.06)	(0.06)
$(\text{Experience}/10)^2$	-0.101	-0.096	-0.092	-0.090
	(0.01)	(0.01)	(0.01)	(0.01)
Constant	9.354	9.545	10.063	10.070
	(0.13)	(0.13)	(0.14)	(0.14)
Adjusted R^2	0.3692	0.3964	0.4060	0.4187
Sample size	1'185			

Robust standard errors in parentheses. # standardized variables. Additional control dummy variables are 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.

The return to schooling, in estimation I, is of 7.9%. 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 population.

As found in Bowles *et al.* (2001) there is a significant drop in the years of schooling coefficients between estimations I and II. The years of schooling coefficient in estimation I measures the full return to schooling. If one assumes all the cognitive skills people possess are acquired or signaled by schooling the years of schooling coefficient in estimation II measures the noncognitive return to schooling.

Estimation III drops the assumptions that all cognitive skills are acquired in school. The years of schooling coefficient is now a mere 3.2, less than half the value found in estimation I. The schooling cognitive skill coefficient is considerably larger than the total cognitive skills coefficient. This is due to signaling. The total cognitive skill measure includes both schooling and non-schooling cognitive skills. The total cognitive skill coefficient is the weighted average of the schooling and non-schooling cognitive skill coefficients.

The inclusion of non-schooling cognitive skills, estimation IV, has virtually no effect on the years of schooling and schooling cognitive skill coefficients. When comparing both cognitive skill coefficients one sees that schooling cognitive skills are four times more likely to be rewarded than non-schooling cognitive skills (0.263/0.064). Cognitive skills identical in nature, but that originate from different areas are rewarded at totally different rates.

Results show schooling is central in determining wages, but extra schooling must be matched with additional schooling cognitive skills to be truly profitable. An additional year of schooling, with no change in cognitive skills, increases wages by 3.2%. This same year of schooling with an increase in cognitive skills yields a wage increase of 7.9%. Because we lack information on the acquisition cost of cognitive and noncognitive skills we can not infer on their respective profitability.

The years of experience coefficients stay virtually constant throughout all estimations. Experience is apparently uncorrelated with cognitive skills, showing that additional years of work experience do not improve or influence cognitive skills. This confirms the results of Green and Riddell (2003) found using Canadian data.

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.

Table 6: Schooling coefficients and components, male

Components	τ	υ	τ'	υ'
	85.5%	14.5%	42.1%	57.9%

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

According to the "classical" model, 85.5% (=0.065/0.076) 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 such a result, schools are a place where people acquire noncognitive skills or are sorted on a noncognitive skill criteria. Such an important noncognitive component also suggests that solely using cognitive skill tests such as PISA (Programme for International Student Assessment), PIRLS (Progress in International Reading Literacy Study) or TIMSS (Trends in International Mathematics and Science Study) to measure schooling quality is largely incomplete.

According to the method developed in this paper, less than half of what the labor market rewards in schooling is noncognitive (42%), or cognitive skills not unobserved in the data. The skills measured in this paper are 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 boost the cognitive component of the return to schooling upwards. Reversely, nearly 60% of what the labor market rewards in schooling is cognitive. Such a finding yields a radically different interpretation on the use of cognitive skill tests as a measure of schooling quality. Accordingly 60% of a schooling quality index should be composed of cognitive skills. Nonetheless to obtain a representative schooling quality index of what the labor market rewards in schooling, noncognitive measures also ought to be included in the index.

5.2.2 Females

Table 7: Log annual earnings, OLS regressions, female

	I	II	III	IV
Years of schooling	0.068	0.062	0.023	0.023
	(0.01)	(0.01)	(0.01)	(0.01)
TCS#		0.064		
		(0.02)		
SCS#			0.268	0.270
			(0.04)	(0.04)
NSCS#				0.031
				(0.01)
Experience/10	0.474	0.477	0.529	0.527
	(0.06)	(0.06)	(0.06)	(0.06)
$(\text{Experience}/10)^2$	-0.078	-0.076	-0.072	-0.071
	(0.01)	(0.01)	(0.01)	(0.01)
Constant	9.489	9.578	10.108	10.114
	(0.11)	(0.11)	(0.14)	(0.14)
Adjusted R^2	0.2551	0.2646	0.2891	0.2919
Sample size		1'013		

Robust standard errors in parentheses. # standardized variables. Additional control dummy variables are father born in Switzerland, mother born in Switzerland, father university degree and mother university degree. TCS=Total cog. skills and SCS=Schooling cog. skills.

The comments expressed for men remain globally valid for women and confirm our results on schooling's components. Results on female wage estimations are always subject to complications linked to a potential selectivity bias and years of experience mis-measurement. The years of schooling coefficient drops, when we include a measure of total cognitive skills, by less than 10%. The drop is of 66%, when we control for schooling cognitive skills.

The cognitive component of the return to schooling, table 8, is considerably higher than what is found when using the "classical" method. Results show close to 70% of what the labor market rewards in schooling is cognitive.

Table 8: Schooling coefficients and components, female

Components	τ	υ	τ'	υ'
	91.2%	8.8%	33.8%	66.2%

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

5.2.3 Correlation and multicollinearity measures

Empirical support to assumptions 2 and 3 of the omitted variable bias development is shown in table 9. The correlation between years of schooling and schooling cognitive skills are positive, large and significantly different from zero. The correlation between years of schooling and non-schooling cognitive skills are significantly different at a 1% threshold.

Table 9: Schooling and cognitive skill correlations

	Male				Female			
	YS	TCS	SCS	NSCS	YS	TCS	SCS	NSCS
YS	1.00	-	-	-	1.00	-	-	-
TCS	0.44	1.00	-	-	0.43	1.00	-	-
SCS	0.72	0.61	1.00	-	0.73	0.59	1.00	-
NSCS	0.00*	0.80	0.00*	1.00	0.00*	0.81	0.00*	1.00

Source: ALL (2003). * significantly different at 1%. YS=years of schooling, TCS=Total cognitive skills, SCS=Schooling cognitive skills and NSCS= Non-schooling cognitive skills.

A potential drawback when one controls for years of schooling, schooling cognitive skills and total cognitive skills is whether the variables are collinear. To be on the safe side we measure the level of multicollinearity in all four estimations. The rule of the thumb, see Chatterjee *et al.* (2006), when measuring the variance inflation factors (VIF) suggests that the VIF value for each variable should remain below 10.

Estimations I and II are canonical wage estimations, the high VIF of the experience variables is inevitable. The inclusion of the schooling cognitive skill and non-schooling cognitive skill variables does not load the model with multicollinearity.

Table 10: Variance inflator factors, VIF

	Male				Female			
Estimation	I	II	III	IV	I	II	III	IV
Years of schooling	1.2	1.4	3.1	3.1	1.3	1.4	3.9	3.9
Experience	14.2	14.2	14.2	14.3	13.8	13.8	14.3	14.3
Experience^2	14.4	14.5	14.6	14.7	13.8	13.9	14.0	14.0
TCS	-	1.5	-	-	-	1.5	-	-
SCS	-	-	5.8	5.8	-	-	7.6	7.6
NSCS	-	-	-	1.0	-	-	-	1.0
Mean VIF	4.1	3.9	4.6	4.3	4.0	3.8	4.8	4.5

TCS=Total Cognitive Skills and SCS=Schooling Cognitive Skills

Other variables not reported.

6 Conclusion

This paper provides innovative support that the return to schooling is predominantly composed of cognitive skills and only mildly of noncognitive skills. Our results challenge previous methods, such as Gintis (1971) and Bowles *et al.* (2001), that suggest up to 90% of the return to schooling is noncognitive. Said differently it is the capacity to process information and apply knowledge the labor market rewards in schooling and not so much personality traits such as self-esteem or perseverance. Data also shows that cognitive skills acquired or signaled via a schooling diploma are several times more likely to be rewarded than identical cognitive skills acquired elsewhere.

It is by splitting the total cognitive skill measure available in our data between schooling and non-schooling ones that we obtain these results. Doing so allows us to drop the hypothesis that cognitive skills are exclusively acquired or signaled by schooling. 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 (*e.g.* commonly referred to as geeks or nerds); from those with little schooling cognitive skills yet high non-schooling cognitive skills (*e.g.* self-made men).

Cognitive skills represent close to 70% of the return to schooling, leaving about 30% to be noncognitive. The measure of cognitive skills employed here represents basic skills, suggesting the estimated cognitive component of the return to schooling may even be a lower bound. Because we ignore their acquisition cost of schooling cognitive and noncognitive skills we can not infer which are more profitable.

A large share of what the labor market pays for in schooling is cognitive and these same cognitive skills are largely profitable when they originate from a schooling environment. As a result policies seeking to use cognitive skill tests as a schooling quality measure and to increase the cognitive quality of formal education are appropriate goals.

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