Ability and Rates of Return to Schooling - making use of the Swedish Enlistment Battery Test

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March 23, 2005

Abstract

The main objective of this paper is to estimate and compare the return to investments in education for men belonging to different parts of the ability distribution. Our ability measure is the achievement test score from the Swedish Military Enlistment Battery. By exploring the measurement error in the test score, i.e. the deviation from the true latent ability level of the individual, we try to predict the expected biases in the "ability specific" returns to education, when using an achievement test as a proxy for ability. We find that a higher score on the Swedish Enlistment test is associated with a higher return to schooling. The relationship between the return to schooling and the test score does however seem to be decreasing in the test score. Thus, it it primarily the ability specific return to schooling for the lower test groups that divert from the average return to schooling. In general, the measurement errors in the test score do not seem to bring about any major biases in the ability specific returns to schooling.

1 Introduction

The return to investments in education might differ considerably between individuals from different parts of the ability distribution. The average return to investments in education is a quite unsatisfactory measure for explaining the individual's choice of utility maximizing

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education level. For a low ability person, investing in an academic education does not necessarily have to bring about any substantial increase in earnings, while an individual from the upper part of the ability distribution might get a return from investing in an academic education that is well above the average return. Furthermore, the well known ability bias in the schooling coefficient may also differ in magnitude between individuals of low respectively high ability.

For an individual to correctly maximize his/her expected lifetime earnings the individual has to be aware of his/her true return to investments in education. If a person does not consider his/her own ability, and ability influences the return to education, the maximizing decision might be made on false grounds. A study performed by Ingram & Neumann (forthcoming in Labour Economics) reports that in the US, for the past several decades the group that fared worst in the labour market was the group who did not invest in specific skills, but with a college education. Juhn, Murphy & Pierce (1993) has shown that the wage inequality in the US has increased since 1970. They assume that the increase is primarily due to an increase in the return to unobservable skills. A recent paper by Gould (2005) reports that the increased inequality can be attributed to an increase in the demand for mental ability and/or the general, unobserved skill within each occupation. Furthermore, Meghir & Palme (2003) has shown that the reform of the Swedish schooling system in the 1950s, which increased compulsory schooling, resulted in a significant and large rise in earnings for individuals above the median ability level but with unskilled fathers. Taking these findings as a starting point, we want to more thoroughly investigate the relationship between ability and the return to investments in education.

The main objective of this paper is to estimate and compare the return to investments in education for men belonging to different parts of the ability distribution. We name this estimate the ability specific return to education. The ability measure used for locating individuals in different parts of the ability distribution, is the achievement test score from the Swedish Military Enlistment Battery. The Swedish Military Enlistment Battery tries to measure cognitive ability and the test is used for allocating individuals into different branches of the military, and to select those who are capable of performing more qualified jobs. The Swedish Military Enlistment Battery is taken by virtually every male Swedish citizen the year when the individual turns 18.

The second aim of this paper is to explore the measurement error in the ability proxy, i.e. the test score from the Swedish Military Enlistment test, and the bias in the ability specific return to education coming from the measurement error in the test score.[1] The measurement error in the test score is assumed to be the deviation from the individual true latent cognitive ability level.

The final objective of the paper is to produce estimates of the return to education for different education levels when controlling for ability. We also assess the question whether log earnings is a linear function of years of schooling or whether "sheepskin effects" exist in Sweden.[2]

When estimating the relationship between earnings and schooling it is commonly assumed that the schooling coefficient is upward biased.[3] When ability is an omitted variable in the earnings equation three different approaches have been used with the intent to capture the true return to education.

In the first approach, and also in the approach used in this study, achievement test scores, measuring cognitive ability, work as indicators for ability. The main problem with this approach is that both schooling and the test score are generated by the same latent ability. This means that using test score as an indicator for ability one has to be aware of the joint causality between schooling and the test score (Hansen, Heckman & Mullen, 2003).

In a study performed by Kjellström (1999), using two separate Swedish data sets, IQ-tests and grades from the end of the sixth year of schooling serve as controls for ability. When controlling for ability, the earning premium for one more year of schooling fell from .052 to .043. Blackburn & Neumark (1995) uses the Armed Services Vocation Aptitude Battery (ASVAB) test as an indicator of ability. They show that the upward bias in the return to education is roughly 40% when ignoring ability. In a similar fashion, Murnane et al. (1995) study how the mathematical skills of graduating high school seniors affect their wage at age 24.

The second approach uses institutional changes in the schooling system, and changes in compulsory schooling laws, as sources for exogenous variations in educational attainment. With these "natural variations" affecting the schooling decision, a causal return to education effect is estimated within an instrumental variable framework. Most of these IV-estimates of the return to education report a higher

[1]Because this is the first study actually using the test score result from the Swedish Military Enlistment Battery in a cross-sectional study we believe the test score has to be thoroughly explored.

[2]"A sheepskin effect" is assumed to exist if degrees or credentials are more important for explaining returns to education than the actual years of schooling completed.

[3]However, if potential high wage earners are induced to leave school early, the schooling coefficient could in fact be biased downward (Griliches, 1977).

return to education than the OLS-estimated return to education (see e.g. Angrist & Krueger, 1991, Card, 1995, Harmon & Walker, 1995, Kane & Rouse, 1993). The results of a study performed on Swedish data by Meghir & Palme (1999), using a reform in the 1950s of the Swedish comprehensive school system as an instrument, are in line with these results.

An explanation for these puzzling results might be that the institutional changes in the school system affect the schooling decision of individuals who, otherwise, would choose a relatively low educational level. Furthermore, given that these individuals have a higher return to education than the average individual, the IV-estimate will give a return to education estimate that is higher than the OLS return to education.[4]

Controlling for family background tends to reduce the estimated return to education by approximately 5-10 percent (Ashenfelter & Zimmerman, 1997, Card, 1995). In an IV-framework, where family background is used as an instrument, the estimated return to education exceeds the OLS estimate. Ashenfelter & Zimmerman (1997) state that this result indicates that the OLS-estimate is upward biased due to omitted variables.

The third approach uses twins, with the intent of capturing the causal return to education parameter. By comparing the earnings of twins with different educational levels, unobserved family differences is eliminated within families. Studies performed on American data report a within-family difference estimate that is about 30 % smaller than the OLS estimated return to education (Ashenfelter & Rouse, 1998, Rouse, 1997).[5] Isacsson (1997) finds that the within-family estimate of the return to education for identical twins in Sweden is .023, or less than 50% of the OLS estimated return, .049.

In section 2 the Swedish Military Enlistment Battery is thoroughly explored.

The theoretical model used for capturing the ability specific return to schooling is is presented in section 3. In section 4 we analyze the measurement errors in the test result from the Swedish Military Enlistment test and the bias in the ability specific return to schooling coming from the measurement error. Section 5 gives a description of the sample data and presents some descriptive statistics. The econometric specification and the empirical results are presented in section 6. Section 7 summarizes the study and discusses the findings.

[4]For further explanations of the upward bias in the IV-estimate of the return to education, see Card (1999).

[5]When the within-family difference estimate is corrected for measurement errors in the schooling variable, the estimate is approximately 10-15% smaller than the OLS estimate.

2 The Swedish Enlistment Battery and Cognitive Ability

The intention with the test result from the Enlistment Battery is to try to represent and numerically measure cognitive ability. The Enlistment Battery has been used for the assessment of intelligence in the Swedish military since the middle of the 1940s. The test results from the Enlistment Battery principally measure a general ability. The information from the test is then used to allocate the individuals into different branches of the military, and to select those who are capable of performing more qualified jobs.

Tests trying to measure cognitive ability or an individual's mental capacity have been undertaken for over a century. The first test for measuring cognitive abilities constructed for practical purposes was produced by Binet & Simon between 1905 and 1911 (Ross, 1988). The method most often used today for measuring and calculating individuals' cognitive abilities is the factor model.[6] A general intelligence factor, G, that influences measures of cognitive performance was first identified by Spearman (1904). The general intelligence factor, G, explains the greater part of all variance in test scores, and is often strikingly similar across race and gender (Cawley, Conneely, Heckman & Vytlacil, 1997).[7] Thus, the variable used in this paper for measuring cognitive ability is in fact the general intelligence factor, G.

Scores in ability tests rise with age and education. Therefore it is evident that the tests principally measure knowledge. For example, the US AFQT (Armed Forces Qualification Test) test score rises with human capital and age (Hansen, Heckman & Mullen, 2003, Neal & Johnson, 1996, Winship & Korenman, 1997). Caroll's (1993) opinion is that differences in cognitive abilities depend on both learning experiences and genetic influences. General ability is closely connected to education and the environment of the individual, which means that the ability is not biologically independent of education and the individual's past experiences. However, even if the general ability is related to the education and environment of the individual, the measure seems to capture something that is closely connected to the cognitive ability of the individual. The general ability, i.e. the G factor, is therefore, probably, a reliable measure of latent cognitive ability, but a measure that is either increased or revealed by schooling and learning.

Herrnstein & Murray (1994) proposed that there exists a rela-

[6]For more information on the factor model, see Johnson & Wichern (2002).

[7]For more information about the G factor, and the other group factors, see Caroll (1993).

tionship between G and socio-economic outcomes such as education, occupational attainment, unemployment, and wages. They argue that there has been a rising return to ability in the US for the last decade and that wages are much closer connected to ability than to education. The general G-factor has also been attributed dominant in explaining job performance (Ree & Earles, 1991) and as the largest contributor to academic performance (Brodnick & Ree, 1995). In a discrimination context, Neal & Johnson (1995) has explained the entire black-white wage gap for young women, and much of the wage gap for young men using the AFQT score. Cawley et al. (1997) consents to the view that G explains social-economic outcomes. However, they maintain that the contribution is modest and that more variables are needed to explain wages and occupational choice. They also find that whether using G or the AFQT as a cognitive ability measure makes little difference in explanatory power in wage regressions. Cawley, Heckman & Vyctlacil (1998) concluded that the rising return to schooling in the US is not driven by a rising return to ability. In 1999 the Ministry of Defence completed a validation of the enlistment results against verdicts from the basic military education. The conclusion was that job performance in the military seems to be connected to a high G-factor (Carlstedt, 1999).

The Enlistment Battery 80, which is the test our sample of individuals has taken, includes four tests, Instructions, Synonyms, Metal Folding and Technical Comprehension. The aim of the Instructions test is to measure the individual's ability to make inductions, while the test Synonyms captures verbal ability. Verbal skills are however also needed for performing well on the Instructions test. Metal Folding is a spatial test, and the fourth test measures technical comprehension. Each test is normalized into a nine-point scale. The values are then, in accordance with the method of factor analysis, summed up and transformed into a new nine-point scale labelled "test score group" (Carlstedt & Mårdberg, 1993).[8]

3 The Ability Specific Return to Schooling

In the basic human-capital model, the relationship between schooling and earnings is independent of ability (Mincer, 1975). The model assumes that all individuals have the same opportunity for investments in human-capital and that the return from the investment is equal for

[8]For more information about the "test score groups" and the separate test results see the Appendix.

all individuals. However, it is unlikely that the return to schooling is constant for all ability levels. An average return to schooling will probably exaggerate the return for low ability groups and underestimate the return to schooling for high ability groups. We therefore follow Becker's (1975) human-capital model, and allow ability to affect the rate of return to investments in education.

Moreover, Griliches (1977) explores the bias in the return to education coefficient when ignoring ability in the earnings equation. In this study, and in most other studies that tries to capture the true return to education, the estimated return to education is the average return to education for all ability levels. Thus, even if the average return to education estimate does not suffer from any severe ability bias the estimate does not have to be an accurate measure for explaining the return to education for individuals with different ability level.

A model that intent to capture the return to education parameter for individuals in different parts of the ability distribution is therefore constructed. The construction of the model is made in a fashion that correspond to using an achievement test score as a proxy for ability. With the model in mind we also discuss the potential biases in the ability specific return to education when using the Swedish Military Enlistment test.

From the following expression of the earnings function the average and unbiased return to education, β, can be determined (Griliches, 1977):

$$y = \alpha + \beta S + \gamma_A A + \varepsilon \quad (1)$$

where A is ability and S is schooling. Letting the return to schooling, in some functional form, depend on ability level we generalize the expression to:

$$y = \alpha + \beta(f(A))S + \gamma_A A + \varepsilon \quad (2)$$

where *f(A)* determines the size of the ability specific return to education for different ability levels.

3.1 Using a Test Score as a Proxy for Ability

Since we lack information of the true ability levels of the individuals we use an achievement test score as a proxy for ability, [9] and receive the expression:

$$y = \alpha + \beta(f(T))S + \gamma_T T + \varepsilon \quad (3)$$

[9]Ignoring ability in the earnings equation results in a, biased, estimate of β. Assuming that schooling and ability are positively related and that the return to ability, γ, is positive, the return to schooling will be upward biased.

Unlike true ability that reasonably is a continuous variable a test score will always be a discrete variable. But besides from not being a continuous variable, we assume at this stage that the test score, T, is perfectly measuring ability. An elementary [10] specification of *f(T)* could be to let the test score affects the ability specific return to education linearly:

$$f(T) = \theta_0 + \theta_1 T \tag{4}$$

Which gives the earnings equation:

$$y = \alpha + \theta_0 S + \theta_1 TS + \gamma_T T + \varepsilon \tag{5}$$

A more flexible specification of the relationship between the test score and the ability specific return to education could be to divide the test score results into M[11] test score groups, where $m \in [1,...,M]$, and write *f(T)* in the following form:

$$f(T) = \delta_1 + \delta_2 + ... + \delta_m + ... + \delta_M \tag{6}$$

where δ_m is M indicator variables, indicating which test score group the individuals belong to. The true ability specific returns to education, β_1 to β_M, could then be estimated from the expression:

$$y = \alpha + \beta_1\delta_1 S + \beta_2\delta_2 S + ... + \beta_m\delta_m S + ... + \beta_M\delta_M S + \gamma_T T + \varepsilon \tag{7}$$

However, even if we have an achievement test score that predicts the true ability, we have to be aware of the fact that such test scores are only proxies for the true ability. And even if the test score is very highly correlated with the true ability level, the relationship can never be perfect. Because of different types of measurement errors in the test score biases in the ability specific returns to education could arise. The magnitude of the biases for different test scores may also be of different sizes.

4 Measurement errors in the Military Enlistment test

Addressing the issue of measurement errors in the test score, we have to start by exploring the test score, T, and the probable reasons why T should differ from A. If we assume that the test score from the Military Enlistment test is correctly measuring ability, the only reason for T

[10] And also a traditional way of specifying an interaction effect.

[11] When using the Swedish Military Enlistment test we end up with 9 test score groups.

to differ from A is measurement errors in the test score. Principally, measurement errors in the test score result in a downward bias in the return to ability, γ.[12] Besides that the measurement errors in the test score biases the return to ability, the measurement errors will also bias the ability specific return to education, because this is an interaction effect between both education and ability. If we denote μ to be the deviation between the true latent ability level of the individual and the test score, the Military Enlistment Battery test might contain two [13] different types of measurement errors.

There are reasons to believe that μ and T might be correlated, i.e. that $Cov(T,\mu)\neq 0$. The first measurement errors that could cause $Cov(T,\mu)$ to differ from zero is that the individuals have different education levels when they take the test. The second problem that might result in a measurement error, and a nonzero covariance between μ and T, is that there might be individuals underachieving on the test with intent. Both these problems will therefore be discussed in detail.

The score on ability tests is known to increase with age and schooling (Cawley, Connely, Heckman & Vytlacil, 1996). Schooling can be seen as a mechanism for both increasing and revealing latent ability. And, in accordance with this view, studies show that schooling increases measured ability by 2 to 4 test score points (Hansen, Heckman & Mullen, 2003, Neal & Johnson, 1996 Winship & Korenman, 1997).

The Swedish Military Enlistment Battery is taken by virtually every male Swedish citizen the year when the individual turns 18.[14] Hence, the measured test score level will therefore depend on the upper-secondary school choice. That schooling affects the test score, means that both the decision to study after compulsory education and the choice whether to study at a vocational respectively a theoretical study programme, creates test score differentials between individuals. [15]

[12]Because the paper aims at capturing the ability specific return to education, and not the return to ability, the bias in the return to ability is not investigated any further.

[13]We ignore the measurement error that distinguishes all proxies, i.e. that $V(\mu)\neq 0$. Instead we focus on the measurement errors that is specific for the Swedish Military Enlistment test.

[14]A small number of individuals takes the test at an older age, primarily because they study abroad for the particular year. But this is probably a minor problem for two reasons. First, the group missing out on the test because of their studying abroad is not a very large group, and secondly, there are no legitimate reasons for believing that $Cov(T,\mu)$ for this particular group should be of any specific sign.

[15]The type of theoretical study programme may also affect the test score differently. Natural science study programmes, where math, physics and other technical subjects are important subjects on the schedule, are often believed to increase cognitive ability more

For two persons having different schooling levels, the achieved test scores for the two persons are not fully comparable. Thinking of the test score as a measure of latent ability, the measure is enhanced if the individual chooses to continue studying after compulsory school. The measured ability will therefore, irrespective of the true latent ability level, be higher for individuals continuing to upper secondary school. But even if the measured ability is higher the true latent ability level does not have to be higher for individuals continuing to upper secondary school. On the contrary, for a given achieved test score level, the true latent ability level must in fact be higher for an individual not continuing to upper-secondary school than for an individual continuing to upper secondary school, if we assume the test score to rise with schooling. Thus, if $E[\mu]$ is larger than zero for the lower test scores level, $Cov(T,\mu)$ will be negative.

For a given achieved test score level, one can assume that individuals either choosing not to continue to upper-secondary school or studying at a vocational upper secondary study programme to have a "true" latent ability level that is on average higher than for the group that decides to continue studying at a theoretical upper-secondary study programme. Is this the case, the heterogeneity in schooling level when the test is taken, might bias the ability specific returns to investment in education. A downward bias in the ability specific returns to education arises if individuals with either a compulsory or a vocational upper-secondary education, for a given test score level, are more likely to earn a higher salary than individuals continuing to a theoretical upper-secondary education, because of their assumed higher latent ability level. [16] For the highest test score levels a significant downward bias in the return to education is however not as likely. This comes from the fact that there is not a large group of individuals with only a compulsory education level achieving a high test score.

The second reason for a measurement errors in the test score is persons intentionally under-performing on the test. It is obvious that some persons will not do their best at a military enlistment test for various reasons. If this occurs frequently we can expect the return to education for the lower test score groups to be seriously biased upward. This is because the expected latent ability for the lowest test

than social science study programmes.

[16] As Griliches (1977) points out, when controlling for ability using a test score, schooling might be negatively correlated with the wage equation residual. For a high ability individual it is not always, from a utility maximizing perspective, preferable to invest in a higher education level, because of different types of investments costs. Forgone earnings for high ability individuals might be considerable and exceed the discounted total gains from education.

Table 1: The Bias in the Ability Specific Return to Education for Low, Median respectively High Achievers on the Test.

Test score group	Low:	Median:	High:
Problem:		(Sign of the Bias)	
Heterogeneity in schooling	-	(-)	0
Persons underachieving	$(+)^a$	0	0

Note: ^{a} Primarily a problem for the lowest test score level.

score groups then is, on average, higher than what the test score tells, i.e. that $E[A|T = m] > m$ for small m.

In table 1 the expected sign of the bias in the ability specific return to education is reported separately for low, median respectively high achievers on the test. The table reports that the return to education for the higher test score levels is unbiased. The problem with heterogeneity in schooling level probably results in a small downward bias in the return to education for the median test score levels. For the lowest test score levels it is uncertain whether the bias is positive or negative. The problem with persons intentionally underachieving on the test may very well outweigh the heterogeneity in schooling problem. In the data description, in section 5, we come back to the problem with measurement errors, and by studying the test score distribution and the schooling variable we can with higher accuracy discuss the potential biases.

5 Data description

In this section we describe the sample data, list the covariates and present some descriptive statistics.

The data is a cross-sectional register data from Statistics Sweden (SCB2003). The data is a full sample, containing every individual in the age group 22-36 living in Sweden in the year 2001. Since we intend to capture the ability specific return to education, we have to restrict the sample to men who have taken the Military Enlistment test.[17] We also restrict the sample to Swedish born individuals, with Swedish born parents. By excluding first- and second generation im-

[17] There is only a small number of women who have taken the Military Enlistment test, and this group of women can hardly be considered a representative sample.

migrants and adopted, we escape problems with ethnic discrimination in the labour market. Furthermore, since we are going to estimate an earnings equation, only men that meet the following conditions are included in our analysis: [i] individuals who are employed, and who have not been studying during any part of the year 2001; [ii] those aged 30 or above; [iii] those with an income from work above 80,000 Swedish crowns. Conditional on these restrictions, the sample is reduced to 228,840 individuals.

Our earnings variable is a measure of annual income from work for the year 2001.

The educational attainment variable, SUN 2000, used in this study is a revision of the former SUN classification adjusted to fit the International Standard Classification of Education (ISCED97). The new revised education measure allows us to compute a years of schooling variable that is qualitatively closer to the correct number of years of schooling an individual has completed, than the years of schooling variable constructed from the former SUN measure. Furthermore, the SUN 2000 education variable is for the year 2001 and describes both the highest level of education achieved and the type of study programme attended. The constructed years of schooling variable goes from nine years of schooling, i.e. completing compulsory school, to twenty years of schooling, i.e. getting a doctor's degree.[18] From the schooling variable eleven indicator variables are constructed, where each of the indicator variables corresponds to a certain number of years of schooling attained. More years of schooling are assumed to correspond to a higher education level. The former SUN years of schooling variable does only contain six different education levels.[19]

Four indicator variables indicating whether the individual has received a degree or not, are also constructed. The first variable indicates whether the individual has obtained a final upper-secondary degree or not. The second indicator variable indicates that the individual has studied at a university or college for at least six months, receiving at least 20 academic points[20] in one subject, but not for two years, which corresponds to 80 academic points, and has not yet received a degree. The third variable indicates that the individual has studied for more than two years (80 academic points) but not for three years (120 academic points) and has not completed a degree. And finally, the fourth indicator variable indicates that the individual

[18]Except for nineteen years of schooling, all potential years of schooling between nine and twenty are contained in our schooling variable.

[19]The former SUN classification system contains the following number of years of schooling; 9, 11, 12, 14, 16 respectively 18 years of schooling.

[20]40 academic points correspond to one year of full time studies or 60 ECTS credits.

has studied at a university or college for at least three years, and has received at least 120 academic points, but not achieved a degree. To indicate which type of study programme the individual has attended, thirteen indicator variables are used in the analysis.

Tables A1 and A2 report descriptive statistics for the educational attainment variables. Table A1 shows that the average schooling level is higher for the former schooling variable in comparison to the newer and revised schooling variable. This is primarily because the revised schooling variable separates out the individuals who reach thirteen years of schooling, a group that formerly was categorized as reaching fourteen years of schooling. This group constitutes about 11.2% of the sample. Another important schooling level that is included in the revised schooling variable is fifteen years of schooling (an education level that earlier was classified as sixteen years of schooling), which 7.5% of the sample reach. Moreover, from table A1 it can also be seen that 8.4% of the sample does not reach a degree. A considerable share, 53% of the individuals has a technical education, which is because we are only studying men. About 14% of the sample has a general education, which in this case corresponds to having a compulsory education as the highest education.

Table 2 reports the distribution of individuals reaching the different education levels for each of the test score groups. The information from table 2 together with our earlier exploration of the measurement error in the ability proxy, i.e. the test score from the Swedish Military Enlistment test, determines the expected biases in the ability specific return for each of the different test score groups. The relative number of individuals, for each of the test score groups, reaching less than twelve years of schooling, indicates how large the problem with heterogeneity in schooling might be. By studying the lower test score groups we might also get an insight into whether people intentionally underachieving on the test, constitutes a problem for the analysis.

When studying the distribution of individuals reaching the different education levels, for the lowest test score group, it does not seem as if there is a large group of persons underachieving on the test with intent. Only 1,6% of the individuals, belonging to the lowest test score group, choose to study at a post upper-secondary education. However, among the individuals with an upper-secondary education there might exist some persons underachieving on the test with intent, which could result in an overestimated ability specific return to education for this test score group. For the second test score group there might also be some individuals underachieving on the test with intent. For test score groups higher than the second we do not believe underachieving on the test with intent is a major problem.

Table 2: The Distribution of Individuals Reaching the Different Education Levels for Each of the Test Score Levels.

Test score group:		*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Years of schooling:										
9	*n*	707	2,881	4,511	4,583	3,416	1,575	499	120	13
	(%)	(39,7)	(28,9)	(19,1)	(11,2)	(6,3)	(3,3)	(1,5)	(0,8)	(0,5)
10	*n*	119	538	936	1,025	831	404	138	29	4
	(%)	(6,7)	(5,4)	(4,0)	(2,5)	(1,5)	(0,8)	(0,4)	(0,2)	(0,1)
11	*n*	871	6,043	15,889	26,906	29,140	16,303	5,093	751	36
	(%)	(49,0)	(60,6)	(67,2)	(65,9)	(53,8)	(33,8)	(15,7)	(5,0)	(1,3)
12	*n*	53	357	1,476	4,441	8,583	8,660	4,693	1,428	171
	(%)	(3,0)	(3,6)	(6,2)	(10,9)	(15,8)	(17,9)	(14,5)	(9,5)	(6,3)
13	*n*	9	46	271	1,305	4,222	7,822	7,778	3,762	583
	(%)	(0,5)	(0,5)	(1,1)	(3,2)	(7,8)	(16,2)	(24,0)	(25,1)	(21,4)
14	*n*	7	75	315	1,197	2,982	4,048	3,282	1,440	223
	(%)	(0,4)	(0,8)	(1,3)	(2,9)	(5,5)	(8,4)	(10,1)	(9,6)	(8,2)
15	*n*	8	30	202	993	3,340	5,402	4,612	2,124	319
	(%)	(0,4)	(0,3)	(0,9)	(2,4)	(6,2)	(11,2)	(14,2)	(14,2)	(11,7)
16	*n*	4	9	56	376	1,472	3,562	5,288	4,220	1,043
	(%)	(0,2)	(0,1)	(0,2)	(0,9)	(2,7)	(7,4)	(16,3)	(28,1)	(38,3)
17	*n*	1	-	2	19	99	251	468	471	100
	(%)	(0,1)	-	(0,0)	(0,0)	(0,2)	(0,5)	(1,4)	(3,1)	(3,7)
18	*n*	-	-	2	4	16	53	112	126	47
	(%)	-	-	(0,0)	(0,0)	(0,0)	(0,1)	(0,3)	(0,8)	(1,7)
20	*n*	-	-	1	5	52	198	448	529	186
	(%)	-	-	(0,0)	(0,0)	(0,1)	(0,4)	(1,4)	(3,5)	(6,8)

Note: Percentages is column percentages.

That individuals have different education levels when the test is taken might bias the ability specific returns downward. Table 2 shows that the share of individuals, with only nine years of schooling, is small for the test score groups five to nine. Furthermore, for all test score groups, except the two highest, there is a considerable number of individuals with only eleven years of schooling. Having eleven years of schooling implies in most of the cases that the individual has studied at a vocational upper-secondary study programme.[21] Whether a vocational upper-secondary education has a positive or a negative effect on the test result is however uncertain. [22]

[21]89% of the individuals with eleven years of schooling have a vocational upper-secondary education.

[22]A vocational study programme is often thought of as providing a lower education level than a theoretical study programme. However, Technical comprehension and Metal Folding constitute half of the military enlistment test, and many vocational study programmes are in engineering or other technical fields (as much as 79% of the individuals with a vocational study programme in our study have it in a technical field of education). The technical study programmes might give an advantage on the Technical comprehension

The test is taken sometime during the second half of the eleventh year of schooling or during the first half of the twelfth year of schooling. This implies that a person with a theoretical upper-secondary education, who takes the test during the second half of the year, has on average received about two more months of schooling than a person with only eleven years of schooling. Taking into account that one year of schooling might increase measured ability by 2 to 4 test score points,[23] the extra two months of education, for the group of individuals taking the test during the second half of the year, is not likely to significantly bias the ability specific return to education. The conclusion reached from studying table 2, is therefore that the heterogeneity in schooling problem, primarily is expected to bias the ability specific return to education downward for the four lowest ability groups. And further, for the two highest test score groups the heterogeneity in schooling level problem can be assumed not to bias the ability specific return to education. A sensitivity analysis will be performed to test if our estimates are heavily biased.

6 Econometrical Specification and Empirical Findings

In this section we discuss the choice of econometric specification and present and analyze the empirical findings.

The usual equation to be estimated when trying to capture the return to education is the Mincer equation. A common formulation of the Mincer equation states that the log of hourly wages should be regressed on years of schooling, work experience and work experience squared, where experience is often replaced by age.[24] Antelius & Björklund (2000) shows that when excluding observations with low incomes hourly wages can be replaced by annual earnings.[25] There has however been a controversy as to whether the years of schooling variable is the proper educational attainment variable for measuring returns to education (Card, 1999). Relaxing the linearity assumption, by introducing dummy variables for each year of schooling, tends to reveal that degrees or credentials are more important for explaining

and Metal Folding tests. Therefore, in comparison to a theoretical study programme, it is uncertain if a vocational study programme affects the test score positively or negatively.

[23] See section 3.

[24] When experience is replaced with age, it is often the case that the estimated return to education is smaller than if experience is used (Mincer, 1974).

[25] When using register data from Statistics Sweden.

returns to education than actual years of schooling completed.[26] This is generally known as "sheepskin effects" or the screening hypothesis.

Accordingly, in the econometric analysis we estimate models with different educational attainment variables with the intent of answering the question if there is such a thing as "sheepskin effects" in Sweden.

6.1 Baseline earnings equation

The baseline econometric model, where we use years of schooling, S, as the educational attainment variable, will therefore take the following form:

$$lny = \alpha + bS + \varphi_1 exp + \varphi_2 exp^2 + \rho X + \varepsilon \quad (8)$$

where b is the ability biased return to education. Furthermore, exp and exp^2 are experience and experience squared[27] and X is a set of covariates.[28] We then add ability, i.e. the test score from the Military Enlistment test, to the earnings equation, and get a measure of the return to education, β, that is, at its best, cleansed from the ability bias. However, if the schooling variable suffers from severe measurement errors, we have to be aware of the fact that the estimated return to education might be biased downward.

In model 1 in table 3 the Mincer equation is estimated with the new revised schooling variable, i.e. the SUN2000 schooling variable, and in model 2 the former SUN schooling variable is used. The schooling estimates show that the estimated return to education is larger when using the revised schooling variable. Thus, with the finer schooling variable with better precision the downward bias in the return to education estimate is reduced. Moreover, using the finer schooling variable also increases the precision in experience which consequently increases the estimated return to experience. When adding the test score from the Military Enlistment test to the model (model 3) the schooling estimate decreases from .080 to .061.[29] Controlling for ability therefore

[26] See, for instance, Hungerford & Solon (1987).

[27] Lacking an actual experience measure we use the standard method of constructing experience, i.e. exp = age - 7 - years of schooling.

[28] We will control for labour market region and family income. If one assumes that individuals from affluent homes might have a higher probability of finding well-paid jobs, and family background is correlated with ability, family background has to be controlled for. The ability measure might otherwise, partly, capture the family background effect. The appendix describes the family income measure and explains the construction of the variable.

[29] Using indicator variables for each of the test score groups, instead of the discrete and ordered test score variable, does not change the results in this table or in table 4.

Table 3: OLS Earnings Equation Estimates.

Independent: variables	(1)	(2)	(3)	(4)	(5)
Schooling(SUN2000)	.080 (.001)***		.061 (.001)***	.074 (.001)***	.056 (.001)***
Schooling(SUN)		.075 (.001)***			
Test Score			.040 (.001)***		.039 (.001)***
Experience	.061 (.002)***	.051 (.002)***	.051 (.002)***	.060 (.002)***	.050 (.002)***
Experience^2	-.002 (.000)***	-.001 (.000)***	-.001 (.000)***	-.002 (.000)***	-.001 (.000)***
Family income	no	no	no	yes	yes
R^2	.189	.190	.210	.196	.215

Notes: In all models we control for labour market region.
Standard errors in parenthesis.

reduces the earnings premium for one more year of schooling by approximately 23%. In comparison to the results found in Kjellström (1999), where the return to schooling estimate decreased from .052 to .043 when controlling for ability, our estimated return to schooling is larger,[30] but the relative decrease in the schooling estimate when controlling for ability is about the same. Bjrklund, Edin, Fredriksson & Krueger (2004) reports that the return to schooling has increased during the 1990s in Sweden, and that the average wage premium seem to be around .060 in 2000. Our estimate of the average wage premium therefore indicates that the return to schooling has increased even more since 2000.[31] The average return of increasing the test score by one level is .04. In columns (4) and (5) of table 3 family income is controlled for. In column (4) family income is added to the model and in column (5) both the test score and family income are included in the model. Irrespective of whether ability is controlled for or not, the schooling estimate decreases by about 8% when family income is taken into consideration, which is in accordance with results found elsewhere (Ashenfelter & Zimmerman, 1997, Card, 1995).

To assess if there are ”sheepskin effects”, the years of schooling variable, S, is replaced with our set of indicator variables for educa-

[30]The specification of the model in Kjellström (1999) is however not in every aspect the same as in our model.

[31]The new SUN2000 schooling variable does however partly explain our comparatively high estimate.

Table 4: Estimates of the Return to Schooling Using Indicator Variables for Each Schooling Level.

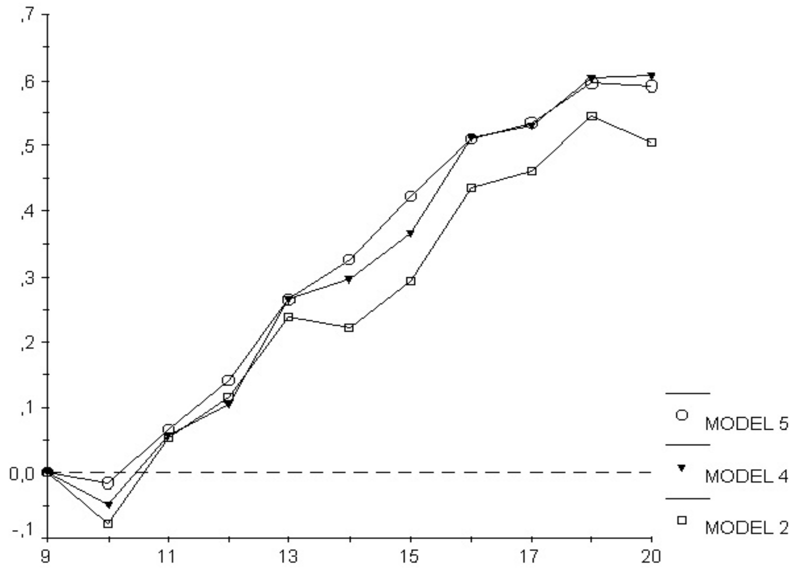
Independent: variables	(1)	(2)	(3)	(4)	(5)
Years of schooling:					
10	-.070 (.006)***	-.077 (.006)***	-.051 (.006)***	-.049 (.006)***	-.016 (.006)***
11	.080 (.003)***	.053 (.003)***	.055 (.003)***	.058 (.004)***	.067 (.004)***
12	.178 (.003)***	.116 (.004)***	.144 (.004)***	.105 (.004)***	.141 (.004)***
13	.333 (.004)***	.239 (.004)***	.254 (.004)***	.264 (.005)***	.264 (.005)***
14	.304 (.004)***	.222 (.004)***	.233 (.005)***	.298 (.005)***	.326 (.005)***
15	.382 (.004)***	.294 (.004)***	.342 (.005)***	.365 (.005)***	.422 (.006)***
16	.548 (.004)***	.435 (.005)***	.425 (.005)***	.511 (.006)***	.510 (.006)***
17	.582 (.010)***	.460 (.010)***	.447 (.010)***	.530 (.013)***	.535 (.013)***
18	.672 (.018)***	.544 (.018)***	.527 (.018)***	.603 (.018)***	.595 (.018)***
20	.635 (.010)***	.504 (.011)***	.477 (.010)***	.607 (.011)***	.591 (.011)***
No upper-sec. degree			-.168 (.005)***		-.158 (.005)***
20-79p			-.060 (.005)***		.033 (.005)***
80-119p			-.068 (.007)***		-.090 (.007)***
At least 120p			-.234 (.006)***		-.210 (.006)***
Study programme	no	no	no	yes	yes
Test Score		.037 (.001)***	.035 (.001)***	.032 (.001)***	.031 (.001)***
Experience	.062 (.002)***	.062 (.002)***	.050 (.002)***	.061 (.002)***	.051 (.002)***
Experience^2	-.002 (.000)***	-.002 (.000)***	-.001 (.000)***	-.002 (.000)***	-.001 (.000)***
R^2	.202	.218	.228	.261	.269

Notes: In all models we control for labour market region.
The reference group has a compulsory education, i.e. nine years of schooling.
Standard errors in parenthesis.

tion levels. Thus, all models estimated in table 4 contain the set of indicator variables for education level. In the first two columns of table 4 the model is estimated without respectively with the score from the Military Enlistment test. In the third model (column 3) we add the variables indicating whether the individual has received a degree or not. The individual's choice of study programme is included in the fourth model (column 4). The fifth model estimated (column 5) contains all of our educational attainment variables.

From columns 1 and 2 we can see that the relationship between years of schooling and the return to education is not perfectly linear. Figure 1 pictures the relationship between years of schooling and the return to education for the second, fourth and fifth models of table 4. Looking at the results from model 2 we find that for the tenth, four-

Figure 1: Returns to schooling



Years of schooling

Note: The earnings premium for a specific years of schooling level, in comparison to a compulsory education, is on the vertical axis.

teenth and the twentieth (i.e. a Ph.D. degree) year of extra schooling the relationship seems to be decreasing.

Model 3 reports that achieving a credential or degree is important if one wants to profit from the full return of an education. To undertake higher education for a relatively long period of time, for more than three years, without reaching a degree is particulary negative, and associated with a 23.4% lower annual income. Also, not completing an upper-secondary education is associated with significantly lower earnings. Hence, the result is a clear indication that sheepskin effects exist in the Swedish education system. What is worth emphasizing is that investments in long higher educations are not economically rewarding if one does not make the effort to reach a degree. The expected income level of a person who has completed three years of academic education, but without completing a degree, is in parity with the expected income of a person who has completed three years of upper-secondary education. Not attaining a degree after many years of studies may be a signal to the employer of a lack of discipline or talent.

Adding study programme dummies to the model tends to make the relationship between schooling and the return to education more linear. From model 4 in figure 1 it can be seen that an extra year of schooling results in a larger earning premium when study programme is controlled for. Furthermore, except for the tenth year of education more years of schooling now increases earnings. However, when the effect from not achieving a degree is controlled for, the negative coefficient for attaining the tenth year of schooling almost disappears. Thus the graph for the full model, i.e. model 5, reveals that the relationship between schooling and the return to education is very close to linear. In the tail of the relationship there is however still some unlinearities. A licentiate degree is for instance rewarded more or less the same as a Ph.D. degree. This is maybe not surprising, knowing that the salaries in the academic sector, where many of the Ph.D.s are employed, are lower than those outside academics.

6.2 Estimating the ability specific return to education

The next step of our empirical investigation is to specify the model used for estimating the ability specific return to education. From expression (7) we specify:

$$lny = \alpha_m + \sum_{m=1}^{9} \delta_m \beta_m S + \varphi_1 exp + \varphi_2 exp^2 + \rho X + \varepsilon \tag{9}$$

where β_m is the ability specific return to education for each of the nine test score groups and δ_m is nine dummy variables indicating which test score group the individual belongs to. However, when analyzing, β_m, the return to education for the different test score groups we have to take the ability specific biases, reported in table 1, into consideration. We also let the intercept, α_m, vary with test score group. Different specifications of expression 9 are estimated and presented in table 5. The ability specific returns to schooling for the nine test score groups are also pictured in figure 2. The figure shows that there seems to be a hump-shaped relation between the return to schooling and the score on the Military Enlistment test. It is only the lowest test score group that diverts from the pattern, i.e. the return to schooling is higher for the lowest test score group than for the second and third test score groups.[32] The reason behind the relatively high return to education for the lowest test score group is probably that some

[32]The difference in the ability specific return to education between the first and the second, and also between the first and the third, test score groups is however not statistically significant.

Table 5: Estimates of the Ability Specific Returns to Education.

Independent: variables	(1)	(2)	(3)	(4)	(5)
Ability Specific Ret. to Ed:					
Test score group 1	.030 (.007)***	.033 (.007)***	.050 (.007)***	.058 (.007)***	.054 (.007)***
Test score group 2	.018 (.003)***	.021 (.003)***	.038 (.003)***	.046 (.003)***	.042 (.003)***
Test score group 3	.025 (.002)***	.029 (.002)***	.045 (.002)***	.053 (.002)***	.049 (.002)***
Test score group 4	.043 (.001)***	.047 (.001)***	.065 (.001)***	.070 (.001)***	.066 (.001)***
Test score group 5	.059 (.001)***	.062 (.001)***	.077 (.001)***	.080 (.001)***	.077 (.001)***
Test score group 6	.068 (.001)***	.069 (.001)***	.083 (.001)***	.085 (.001)***	.081 (.001)***
Test score group 7	.073 (.001)***	.072 (.001)***	.084 (.001)***	.085 (.001)***	.081 (.001)***
Test score group 8	.071 (.001)***	.069 (.001)***	.079 (.001)***	.079 (.001)***	.075 (.001)***
Test score group 9	.064 (.003)***	.059 (.003)***	.069 (.003)***	.068 (.003)***	.064 (.003)***
No upper-sec. degree		-.160 (.004)***		-.175 (.004)***	-.173 (.004)***
20-79p		-.008 (.004)*		.061 (.004)***	.057 (.004)***
80-119p		-.102 (.006)***		-.082 (.006)***	-.082 (.006)***
At least 120p		-.222 (.005)***		-.189 (.005)***	-.187 (.005)***
Experience	.071 (.002)***	.063 (.002)***	.060 (.002)***	.054 (.002)***	.052 (.002)***
Experience^2	-.002 (.000)***	-.002 (.000)***	-.002 (.000)***	-.001 (.000)***	-.001 (.000)***
Study programme	no	no	yes	yes	yes
Family income	no	no	no	no	yes
R^2	.213	.224	.255	.266	.269

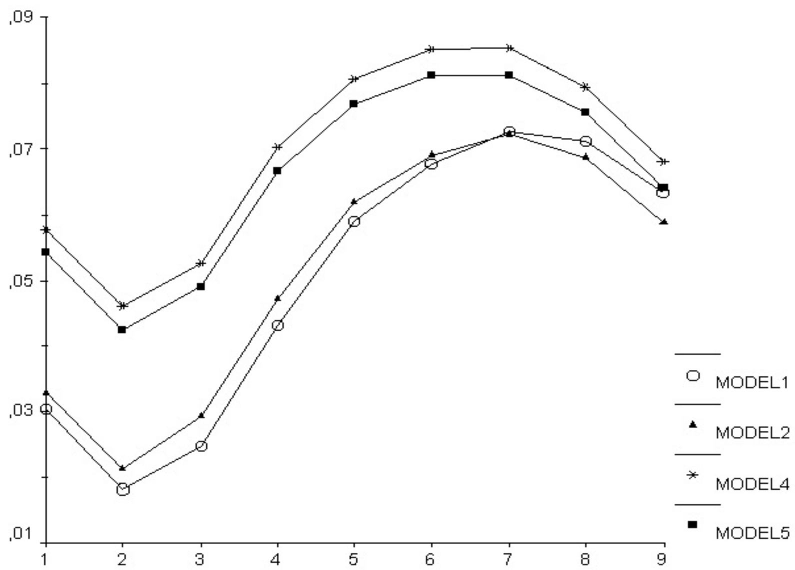
Notes: In all models we control for labour market region.
Standard errors in parenthesis.

otherwise relatively high-achieving persons underachieve on the test with intent. The problem with people intentionally underachieving on the test probably biases the return to education estimates for the lowest test score level more than does the heterogeneity in schooling level problem. The return to education for the second test score group might also be slightly overestimated due to persons underachieving on the test with intent.

The hump-shaped relationship between the return to schooling and the score on the Military Enlistment test is surprising and has to be more thoroughly investigated. From a human capital perspective it is strange that the most talented people should have a lower return to schooling than the groups just below them in ability. The sensitivity analysis to be found in the next section tries to question this result. However, the finding does not mean that the highest test score groups on average earn less than individuals belonging to test score group seven. It only implies that the return to one extra year of schooling is higher for the seventh test score group than for the two highest test score groups.

The curve furthest down in figure 2 illustrates the first model of table 5, where we only control for experience and labour market region. Model 2, in figure 2, shows the ability specific returns to schooling, when the variables indicating whether the individual has received a degree or not have been added. In model 4 we add study programme, and in model 5 also family income is included. One can easily see that the ability specific return to schooling increases for all test score groups when study programme and information on whether the individual has attained a degree or not, are taken into account. Merely taking into account whether the individual has attained a degree or not does, however, decrease the ability specific returns to schooling for the two highest test score groups. When adding family income to the model, which is done in model 5, it is obvious that the ability specific returns to schooling for all test score levels decrease. The decrease is however small and does not seem to change the relationship between the return to schooling and the score on the Military Enlistment test.

Figure 2: Ability Specific Returns to Education



Test Score Group

Note: The return to schooling is on the vertical axis.

The first model of table 5 shows that for the three lowest test score groups the return to schooling is below .025.[33] For the group of individuals achieving at least six on the Military Enlistment test the ability specific return to education lies around .07. However, the largest increase in the ability specific return to education exists when going from the third to the fourth test score group. The sharp increase in the ability specific return to education when going from the third to the fourth test score group, and also when going from the fourth to the fifth test score group, might partly depend on the heterogeneity in schooling level problem. We have earlier found that it is primarily the ability specific return to education for the four lowest test score groups that might be biased downward. Thus, given this assumption, the sharp increase in the ability specific return to education would probably partly be smoothed out if the downward bias could be eliminated.

Again, to assess whether the relationship between schooling and the return to education is linear for the different test score groups we replace the years of schooling variable with our eleven years of schooling indicator variables. By categorizing the nine test score groups into three test score levels, low, medium and high [34] and combining these with the years of schooling indicators we receive 33 test score/years of schooling variables, each variable corresponding to a certain test score level/years of schooling combination. In figures A1, A2 and A3 the returns to schooling are pictured for the different test score groups. Figure A1 illustrates the relationship when controlling for experience and labour market region. In figure A2 the type of study programme is added, and in figure A3 both study programme and information on whether the individual has received a degree or not, is included. Figure A3 shows that the result found earlier, that the relationship between earnings and years of schooling becomes almost linear when study programme and "sheepskin" effects are controlled for, is true for all test score groups.[35] Another interesting result found in the figures, is that it is merely individuals belonging to the highest test score group that seem not to gain an earnings premium from a Ph.D. degree. Figure A1 and figure A2, where we do not control for "sheep-

[33]If we assume that the return to schooling for the lowest test score group is overestimated.

[34]The low test score level includes the test score groups one to three, the medium test score level the test score groups four to six, and finally the high test score level includes the test score groups seven to nine.

[35]We disregard the right-hand side of the relationship for the lowest test score group, because of the small number of individuals with a test score of three or below, who reach more than 16 years of schooling (see table 2).

skin" effects, report that low achievers on the military enlistment test, i.e. those with a test score below four, have a lower earnings premium for twelve years of schooling than for eleven years of schooling. But taking into account, in figure A3, whether the individuals achieve a degree or not changes this result. Hence, individuals with a low result on the Military Enlistment test seem to have some problems finishing an upper-secondary education of three years.

6.3 Sensitivity Analysis

By estimating the ability specific returns to schooling for sub-samples of the total sample we can check the stability of the results, and test whether the non-random measurement errors are heavily biasing our results. The sub-samples of individuals are restricted to groups of individuals within different parts of the education system. Estimating the relationship between the test result on the Military Enlistment test and the return to eduction, for smaller parts of the education system, principally exposes whether the estimates are stable and can be applied all over the education system. Non-random measurement errors might be one source of unstable results.

The relationship is therefore estimated for the following years of schooling intervals; 9-12, 9-17, 12-17, and 13-17 years of schooling.[36] When studying the pre-academic education levels, i.e. 9 to 12 years of schooling, besides from checking the stability in the results, we try to investigate the problem with persons intentionally underachieving on the test. By excluding individuals with either a licentiate or a Ph.D degree, i.e. those with more than 17 years of schooling, we test the accuracy in the hump-shaped relationship between the result on the enlistment test and the return to schooling. Restricting the sample, to individuals with 12 to 17 years of schooling, the return to schooling for the different test score groups should not be biased because people have different education levels when they take the test. Also excluding the individuals with 12 years of schooling, the relationship is estimated separately for the sample of individuals with an undergraduate education level.

Figure A4 illustrates the ability specific returns to schooling for the whole sample, i.e. for all of the years of schooling levels, and for the sample of individuals attaining 9 to 12 years of schooling. On the whole, the relationship between the test score result and the return to schooling, seems to be stable when the sample is restricted to the compulsory and the upper-secondary education levels. The upward

[36]In the estimates that follow we do not control for either the type of study programme or for whether a person has achieved a degree or not.

bias in the ability specific return to schooling for the lowest test score group seems to be somewhat smaller, when we exclude the individuals reaching an academic education. However, the estimates are probably still biased upward because of the problem with people intentionally underachieving on the test. In figure A5, where we exclude the graduate education levels, the hump-shaped relationship completely disappears. Thus, also for the highest test score levels the relationship between the score on the enlistment test and the return to schooling is positive. But even if the earnings premium for one extra year of education increases with the result on the enlistment test the increase seems to be diminishing.

In figure A6, where we test the heterogeneity in schooling level problem, we have to be aware that the ability specific return to schooling estimates are heavily overestimated for the lowest test score groups because people intentionally underachieve on the test. The graph shows that the returns to schooling are about the same, or somewhat lower, for the test score groups four to nine when we exclude the education levels 9 to 11. This result indicates that the ability specific return to education for the test score groups four to nine are not underestimated because individuals have different education levels when they take the test. If the ability specific returns to schooling estimates were underestimated, the estimates for the test score groups in the middle of the ability distribution would be higher when excluding the education levels nine to eleven, in comparison to the estimates for the whole sample. For the three lowest test score groups the heterogeneity in schooling level problem might of course, partly, explain the high return to schooling for these groups, found in figure A6. But because the return to schooling does not seem to be underestimated for the fourth test score group we do not believe that the returns to schooling are underestimated for the three lowest test score groups either.

Illustrating, in figure A7, the relationship separately for the undergraduate education levels (13-17), reveals two interesting features. First, the returns to schooling decreases substantially (as compared to the 12-17 education levels in figure A6) for most of the test score groups. Since beginning an academic education is rewarded with a relatively large earnings premium, [37] the estimated return to schooling is reduced when leaving this earnings premium out. Secondly for the test score groups one to four the return to one extra academic year of education is not significantly different from zero.[38]

[37]From table 4 it can be seen that there is a large earnings premium when going from the twelfth to the thirteenth year of schooling, i.e. beginning an academic education.

[38]Given that the earnings premium for beginning an academic education is excluded.

7 Conclusions

The results of our study indicate that a higher score on the Swedish Military Enlistment test is associated with a higher return to schooling. Hence, referring to an average return to schooling is a quite unsatisfactory measure for describing the return to schooling for individuals from the upper respectively the lower part of the ability distribution. Since the positive relationship between the return to schooling and the score on the Military Enlistment test seems to be decreasing in the test score, it is primarily the ability specific return to schooling for the lower test groups that divert from the average return to schooling. Particularly the lowest test score groups do have a problem completing (i.e. getting a degree) a three-year upper-secondary education programme. Furthermore, the sensitivity analysis has also shown that individuals belonging to the four lowest test score groups do not seem to receive any significant return from a higher education, besides the earning premium from beginning the higher education. Taking into account the fact that people intentionally underachieve on the test, the lower test score groups appear to have a return to schooling that is below .025. The return to schooling seems to be about .06 for individuals in the middle of the ability distribution. One more year of education for individuals from the upper-part of the ability distribution is rewarded with an additional 2%, i.e. the return is .08.

The hump-shaped relationship between the return to schooling and the score on the enlistment test disappears when the sample of individuals with a licentiate or a Ph.D. degree are excluded. This is probably, partly, because people with a licentiate or a Ph.D. degree often are high-achievers on the test, but employed in the academic sector were salaries are relatively low. Another explanation might be that these people have not yet acquired a substantial amount of work experience and are still investing in on-the-job training, an investment that is often "paid" by lower earnings.

When controlling for study programme and for whether an individual has completed a degree or not, the relationship between years of schooling and earnings becomes almost linear. The study also shows that "sheepskin" effects exist in Sweden. It is particularly negative to study for a relatively long time at a higher education institution without completing a degree. Studying at a higher education institution for three years without completing a degree is associated with an expected income level that is in parity with the expected income of a person who has completed three years of upper-secondary education.

It is primarily the problem with people intentionally underachieving on the test that bias the ability specific return to schooling. The study shows that the ability specific return to schooling for the test score groups in the lower part of the test score distribution seem to be biased upwards because people underachieve on the test. The heterogeneity in schooling level problem does, however, not seem to bias the ability specific returns to schooling a great deal.

We have also seen that the new, revised education measure allows us to compute a schooling variable that is closer to the correct number of years of schooling that an individual has completed. With this finer schooling variable with better precision we consequently get a return to schooling estimate that is higher than if the earlier education measure is used.

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Appendix

The test score groups

The data contains both the "test score group" variable, and the results on the separate tests. The transformation of the results on the separate tests into the nine-point scale has however changed during the time period. But because our data contains the results on the separate tests we are able to construct a test score measure that is time consistent, i.e. where the method for calculating the nine-point scale is the same for the entire time period. For 2,7% of the observations there is missing information for one, two or three of the separate test scores results. In these cases we use the average of the other test score results as a proxy for the missing test score result. Because excluding these observations from the sample do not change our estimates we decide to keep them.

Using the sum of the separate test score results instead of G in the wage regressions does not change any of the results found in the paper. But if we instead were to divide the test score groups into 10 equally large groups, i.e. deciles, based on either G or the sum of the separate test score results the estimates changes in the tails of the ability distribution. In fact, this means that we lose the opportunity to analyze what takes place in the end of the tails.

Family Income

Family income is computed in the following manner. Estimates of the mother's and father's average earnings, based on the earnings for the years 1970, 1975 and 1980, are first computed. All earnings are in 1980-years prices. If any of the earnings for the three years is zero, an average of the remaining positive earnings is computed. We then add the mother's and father's average incomes and obtain a measure for the family income.

Table A1: Descriptive Statistics for the Educational Attainment Variables.

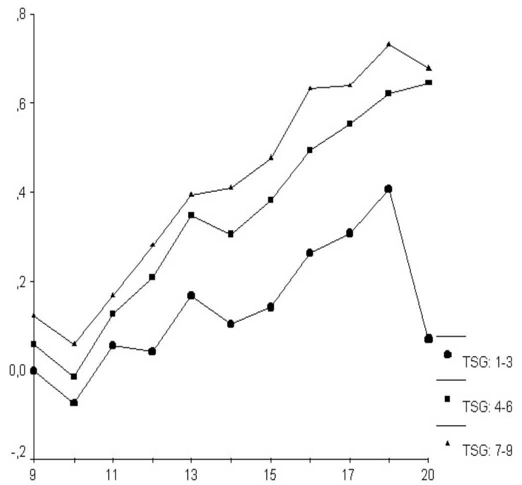
Variable:	*N:*	*Mean:*
Schooling(SUN2000)	228,840	12.11
Schooling(SUN)	228,840	12,29
No upper-sec. degree	5,934	.026
20-79p	4,098	.018
80-119p	2,988	.013
At least 120p	6,073	.027
Total without a degree	19,093	.084
Study programme:		
General	31,099	.136
Pedagogic	5,196	.023
Human. or Cultural	3,886	.017
Soc. or Journalistic	3,463	.015
Econ, Admin. or Comp.	34,795	.152
Law	1,979	.009
Natural science	2,069	.009
Technical	121,828	.532
Agricul. or Forestry	6,054	.026
Low Medicine	4,941	.022
High Medicine	1,743	.008
Services	10,979	.048
Missing	808	.035

Table A2: Comparison of the schooling variables.

Years of schooling:	*Schooling(SUN2000):*	*Schooling(SUN):*
9	18,305	18,305
10	4,025	-
11	101,032	105,056
12	29,862	29,862
13	25,798	-
14	13,569	39,367
15	17,030	-
16	16,030	34,471
17	1,411	-
18	360	1,779
20	1,419	-

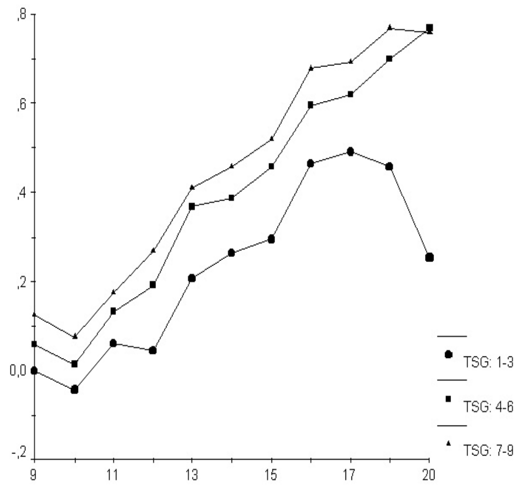
Figures A1-A3: Separate returns to education estimates for different test score levels.

Figure A1



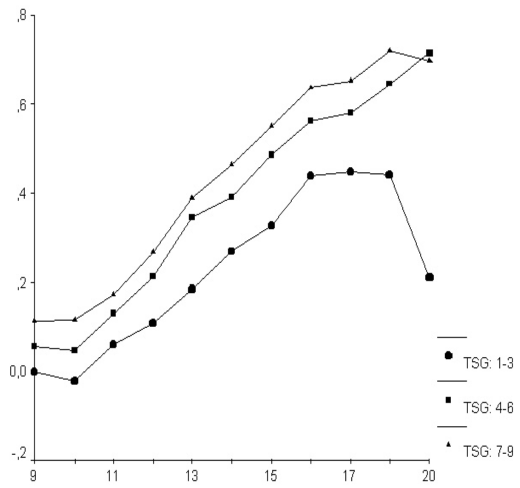
Years of schooling

Figure A2: Controlling for study programme.



Years of schooling

Figure A3: Controlling for study programme and degree.

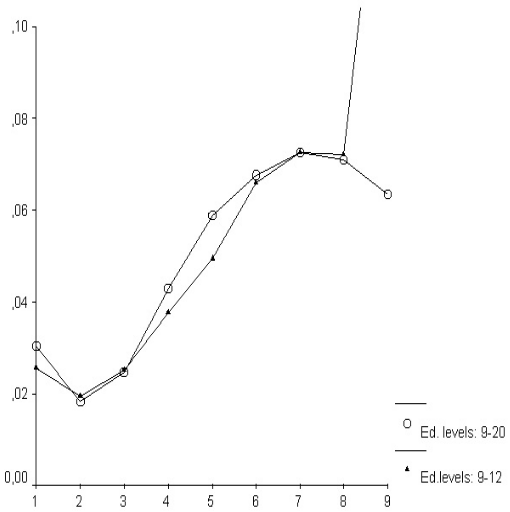


Years of schooling

Note: In all models we control for work experience, work experience squared and labour market region.

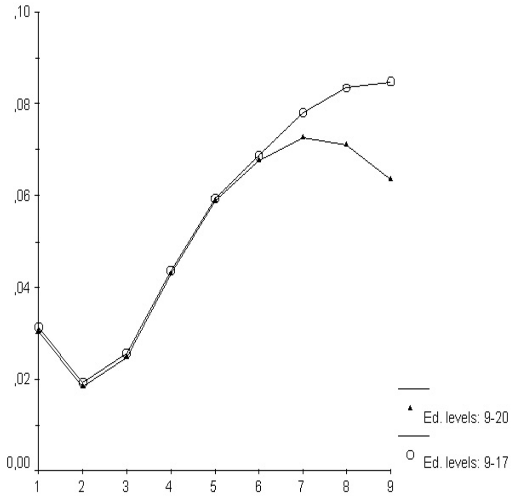
Figures A4-A7: Testing the Stability in the Ability Specific Returns to Schooling.

Figure A4



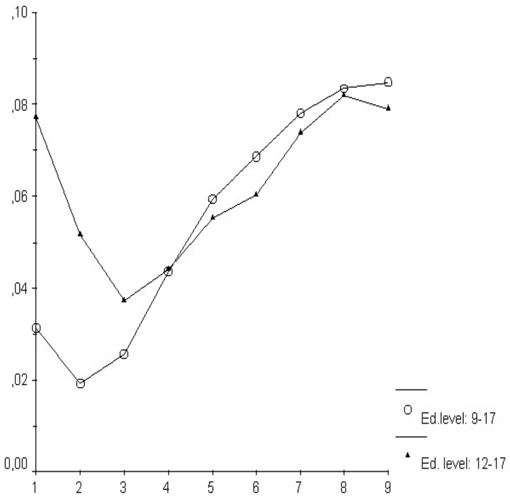
Test Score group

Figure A5



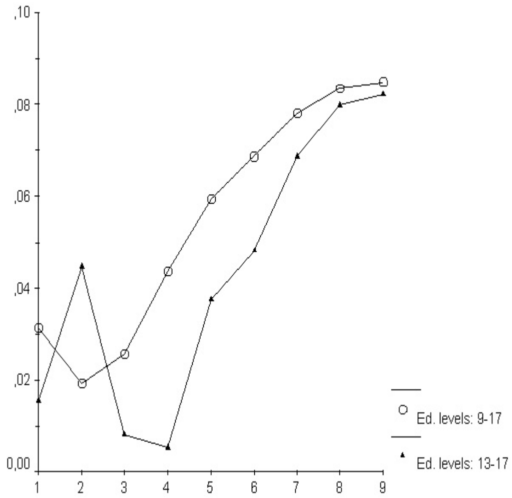
Test Score group

Figure A6



Test Score group

Figure A7



Test Score group