Increasing Returns to Schooling by Ability? A Comparison Between US and Sweden?

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2011

Total number of authors:
2

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A Comparison Between the US and Sweden[*]

by

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Abstract

This study uses US survey data (NLSY) and Swedish register data to estimate the relationship between returns to schooling and ability for each country separately. A significant and positive relationship is found for Sweden but not for the US. The purpose is to propose an explanation for why such differences might occur. While many studies have focused on whether credit constraints result in inefficiencies in the schooling market, this study answers the opposite question: whether weak credit constraints lead to inefficiencies, in other words in an overuse of the schooling system. It is argued argue that the US schooling system more effectively sorts out education investments with a low rate of return to schooling than the Swedish schooling system. Therefore, an imperfect allocation of individuals going to higher education in Sweden makes a relationship between returns to schooling and ability observable in Sweden but not in the US. Since the relationship between returns to schooling and ability is the same when the schooling systems of the two countries is similar, that is at lower levels of education, it is indicative of the fact that this explanation may be correct. Of course, the empirical findings in this study are not convincing evidence on their own, but the findings suggest and agree with such an explanation.

JEL classification: J24, I21

Key words: Cognitive ability, return to schooling, credit constraints

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1. INTRODUCTION

For Sweden, Nordin (2007) shows that there is a strong and positive relationship between returns to schooling and ability. For individuals belonging to the lower part of the ability distribution, the return to schooling is about 60 percent lower than for individuals in the middle of the ability distribution. For high ability levels, the return to schooling is about 30 percent higher than for those belonging to the middle of the ability distribution.

The same relationship is not evident in the US when using a similar empirical model. For instance, Altonji and Dunn (1996) do not find a significant interaction effect between ability and years of schooling when using a standard Mincerian wage equation. Yet, even if the relationship is weaker in the US than in Sweden, there are studies indicating that there is heterogeneity in returns to education in the US as well (see Carneiro, 2002; Carneiro et al., 2001, 2003). Carneiro et al. (2001, 2003) extend the policy treatment literature and estimate joint distributions of counterfactual returns to education. Using NLSY data and the ASVAB cognitive test score battery, they find that the return to college education is significantly lower for low ability individuals who are less likely to attend college, or are at the margin, than the average individual. For 7% of the college graduates the return to college is even negative.

Hence, when estimating the relationship between the returns to schooling and ability in a Mincerian framework, the results differ between Sweden and the US. The question is why? Or more precisely, why does the relationship between returns to schooling and ability not show up for the US when using a standard wage regression, knowing that there is in fact heterogeneity in returns to education by ability.

The purpose of this study is to propose an explanation for why such differences might occur. It argues that measured differences in the relationship between returns to schooling and ability could depend on differences in the schooling systems between Sweden and the US, especially at higher levels.

We believe that differences in the schooling systems are an obvious first choice. When comparing the schooling systems for the US and Sweden, one finds differences primarily at higher education levels. Due to being severely subsidized, Sweden has a schooling system with relatively weak credit constraints for entering higher education

levels. In the US, where the credit constraints are stronger at these levels[1], the economic incentives probably induce more carefully planned college investment decisions. Some suggest that the reason why individuals with a high return to schooling do not go to school without a school intervention[2] is the credit constraint (Card, 2001), while others are convinced that credit constraints cannot be the explanation (Cameron and Taber, 2004; Cameron and Heckman, 1998, 2001; Shea, 2000; Keane and Wolpin, 2001; Stinebrickner and Stinebickner, 2008). Moreover, the system for admitting students into college differs considerably between the countries[3].

Hence, while many studies have focused on whether credit constraints in the present US school system (with programs supporting financially constrained individuals) result in inefficiencies in the US schooling market, our study answers the opposite question: do weak credit constraints lead to inefficiencies, that is in an overuse of the schooling system?

To ascertain whether the returns to schooling vary with ability, this study uses the same empirical approach as Nordin (2007), where the model specification is in accordance with the Mincerian framework (Mincer, 1974). Instead of an ordinary interaction effect between ability and years of schooling, Nordin uses a pooled income equation with separate years of schooling variables for each ability group. The model is better in illuminating ability differences in the returns to schooling. To further analyse the ability-variation in returns to schooling, family background differences are also considered. With data from NLSY (National Longitudinal Survey of Youth) for the US and data from Statistics Sweden, we are able to perform the same analysis for the two countries. Ability is here measured as performance on a cognitive test. For the US we use the AFQT test, while for Sweden we use the Swedish Military Enlistment test, which is a similar cognitive test to the AFQT.

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[1] Since there are no tuition fees in Sweden, it is actually the price of going to higher education that is lower in Sweden than in the US, and high prices in the US may induce credit constraints. Yet, to keep to the familiar concept in the literature, we use the term "credit constraint" when referring to high marginal costs of education.

[2] It is often agreed that an IV approach estimates the return to schooling for the groups who are induced to go to school by a certain school intervention. For this group of individuals the return to education is often high.

[3] An overall judgment of every eligible individual is often carried out in the US. In Sweden, the system is uniform and equitable. Section 2 describes the schooling systems in the two countries.

As expected, this study finds that the relationship between returns to schooling and ability differs between the US and Sweden at higher levels of education. In Sweden, the returns to schooling significantly increase with ability, while that is not the case for the US. The results (the way the estimated income premiums in Sweden, but not in the US, vary with the education level and over the ability distribution) correspond with the predictions of the optimal schooling model. The optimal schooling model outline that returns to schooling may vary with ability when the relationship between ability and costs is weak. Moreover, when considering family background interactions, the results also agree with the theory.

Furthermore, when the schooling systems of the two countries are more similar, that is at lower levels of education, the average high school income premium is the same, and small, for individuals in the lower part of the ability distribution. Hence, when the schooling systems are different, so is the relationship between returns to schooling and ability. When they are the same, so is the relationship, which indicates that our hypothesis is correct: too weak credit constraints when entering higher levels of education in Sweden induce education investments with a low rate of return to schooling.

The paper is structured in the following way. Beginning with a model for explaining heterogeneity in returns to education, section 3 describes the schooling systems in the two countries. The data and descriptive statistics are contained in Section 4, and the results are shown in Section 5. Section 6 concludes the paper.

2. THE OPTIMAL SCHOOLING MODEL

According to the optimal schooling model, individuals' schooling level, S, is determined in the intersection between the marginal rate of return (MRR) to schooling and the marginal cost (MC) of schooling[4]. Following Card (1995), the MRR, $\beta_i(S)$, for different individuals, i, is defined as:

(1) $\beta_i(S) = b_i - k\,S$

where the MRR expression is assumed to vary between individuals because of different levels of ability, b_i. The MC, $\delta_i(S)$, expression:

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[4] The first order condition of U=log y (S)–C(S) (where the earnings, y, and the costs of studying, c, depend on years of schooling, S) gives the optimal stopping rule.

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(2) $$\delta_i(S) = r_i - m S$$

varies due to differences in costs (tastes), r, for education. Thus, the model recognizes two sources of heterogeneity: 1) ability-related differences in the marginal rate of return to education at each schooling level; and 2) differences in the tastes (costs) for schooling. Figure 1 illustrates how different combinations of MMRs and MCs give different solutions to the education investment decision.

Figure 1 about here

If higher ability individuals are brought up in more affluent families[5], it is reasonable to assume (Card, 1995) that a negative correlation exists between ability, b, and costs, r. In other words, the more able have better (family) funds to pay for education[6].

Moreover, assume that we have three types of individuals with different MRRs, where MRR_1 is a low ability type, MRR_2 is a middle ability type, and MRR_3 is a high ability type. With a perfect correlation between b and r, the type 1 individual with MRR_1 faces MC_1 (the type 2 individual with MRR_2 faces MC_2 etc.). As Figure 2 illustrates, the marginal rate of return to schooling is thus equal for all three types of individuals, although the level of education increases with the ability level of the individual.

Figure 2 and Figure 3 about here

However, as one lowers the correlation between b and r the result changes. When the correlation between b and r is zero, the three types of individuals have the same probability of facing the different MCs. This means that the MC expression can be generalized to be equal for all types of individuals. As Figure 3 illustrates, the important implication is that the marginal rate of return will increase with b. The model also reveals that the difference in education levels between the ability groups gets smaller when the correlation between b and r decreases.

Hence, the model predicts that when the schooling system is constructed so that the relationship between ability and costs is weak, the returns to schooling increase with ability if, for example, the schooling system contains few credit constraints.

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[5] Caused by either inheritance or family background effects.
[6] The correlation between b and r also strengthens if the learning costs of education are higher for low ability individuals.

2.1. *Restricting the model to certain MC types*

As long as the correlation between ability, b, and costs, r, is less than one, for a certain ability type, there is heterogeneity in the MCs (we move along the MRR). Yet, as we restrict our focus to a certain MC-slope, the heterogeneity in MCs of a certain ability type disappears (we are at a certain point of the MRR curve). Therefore, this restriction will increase the ability-variation in the marginal rate of returns to schooling. In other words, for the general population the marginal rate of return for a certain ability type will be a weighted[7] average of the marginal rate of returns for each MC level. However, in restricting the focus to a certain MC-level, we move along an increasing MC-slope. Figure 4 illustrates the average returns to schooling for each ability type when 0<corr(b,r)<1. The figure also shows that the returns to schooling increase more with ability for individuals with MC_3 (or any of the other MCs).

Figure 4 about here

Therefore, in a system with credit constraints the model predicts that when restricting the focus to certain socioeconomic groups, the ability-variation in the returns to schooling increases. However, in a schooling system, similar to the Swedish with the same MCs for all socioeconomic groups, the ability-variation in the returns to schooling is equal for all types. Thus, in a country-comparison the ability-variation in the returns to schooling, when restricting the analysis to certain socioeconomic groups, should be more similar.

3. THE SCHOOLING SYSTEM IN THE TWO COUNTRIES

3.1. *Sweden*

The first nine years of schooling are compulsory in Sweden. During the time period in question, the individuals were then able to choose either a two- or three-year upper secondary education. Those who either completed a two- or three-year upper secondary education, or were at least 25 years old and had at least four years of work experience, were eligible for college or university[8]. An undergraduate degree is finished in three to

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[7] The weights depend on the correlation between ability, b, and costs, r.
[8] The individual also must show proof of proficiency confirm in Swedish and English. For many study programmes, the individual must also pass some certain courses, often in Swedish and/or maths.

five years depending on the field and whether one chooses a bachelor's or a master's degree. Graduate education consists of an additional four years of education.

Higher education in Sweden is publicly administered and publicly financed. A fixed number of places are available in higher education[9]. When the eligible applicants exceed the places available, there are two ranking systems to decide who gets a place. The individuals are separately ranked according to their average upper secondary grade and the score in a scholastic aptitude test[10]. And work experience adds points to the scholastic aptitude test. Since those with a two-year upper secondary education are ranked on their own and work experience affects the ranking score in the scholastic aptitude test, who places in higher education in Sweden is not decided purely on scholastic ability.

Studying in Sweden is always free of charge. In order to study at a higher level, the individual is offered a grant and loans. The grant makes about up 30% of the total study grant, that is both the grant and the loan. The rules for repaying the loans are favourable[11].

3.2. *US*

Schooling is compulsory in the US; however, the age range for which school attendance is required varies from state to state. Most children finish high school at grade 12. Some states allow students to leave school between the ages of 14 to 17, in other words before finishing high school, and other states require students to stay in school until age 18. Higher education in the US (college or university) commonly consists of four years of undergraduate education ending in a bachelor's degree. Graduate education ends in a master's degree (often two years) or a doctorate (four years).

The higher educational system is largely decentralised. Public universities are administered solely by the individual states, although federal grants are often given to the

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[9] The number has been fairly stable during the period when the current cohorts went into higher education.

[10] Taking the scholastic achievement test is optional. Before 1991, the test was only available for those who were at least 25 years old and had at least four years of work experience. Since 1991, the test has been used for all applicants, which implies that the individual is ranked in both systems.

[11] The student repays 4% of the annual before-tax income from work. When the student retires, the loan is written off.

state universities. In addition, there are many private (profit or non-profit) universities, which are often the most prestigious schools.

In principle, every university in the US has its own rules for admitting students. Generally, individuals go through an "interview" process. Many different aspects are taken into account: high school results and other high school merits, SAT scores, letters of recommendations, and other relevant background conditions. Most schools also consider more subjective factors such as a commitment to extracurricular activities, a personal essay and an interview. Hence, the system for admitting students is very ambitious and it is likely that, relative to Sweden, those admitted in the US, on average, are better suited for higher education.

Tuition is charged at almost all American universities, and the private universities often charge much higher tuitions than the public universities (that are partly state funded). To pay the tuition (most lack the financial means to pay up front), the students generally rely on student loans or scholarships. Scholarships may either be need-based aid (based entirely on the student and family's financial situation) or a merit-based aid (given to students with exceptional academic promise). The student loans programmme allows students to borrow money at a reduced interest rate and defer payment until they are no longer in school.

4. DATA

The NLSY consists of a nationally representative sample of 12,686 American men and women. In 1979, when they were first surveyed, they were between the ages of 14 and 21[12]. The individuals were interviewed annually until 1993. Since 1994, the interviews have been conducted biannually. Our sample is restricted to white males who were interviewed in 1993, in other words when the individuals were between the ages of 28 and 36, which was the same age range as for their Swedish counterparts in 2001[13]. In 1993, 2,240 white males were interviewed. Of these 2,132 have taken the ASVAB test.

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[12] Actually, three subsamples make up the NLSY: i) 6,111 civilian youths; ii) an oversample of 5,295 civilian Hispanics, blacks and economically disadvantaged whites; iii) a military sample of 1,280 youths.
[13] Using different years, 1993 for the US and 2001 for Sweden is not expected to create problems. In 1993 there was a huge economic crisis in Sweden, and since 1993 Sweden has become less financially regulated and income inequalities and returns to schooling have increased. Therefore, in many aspects Sweden in 2001 was more similar to the US in 1993, than it was in 1993.

Following Barrow and Rouse (2005), we also exclude students, those in the military, self-employed, and those The final sample consists of 1,690 US males. The sample of US men is rather small. To increase the sample, 950 African-Americans and 1,496 females are (when conducting sensitivity tests) added to the analysis.

The Swedish data is register data held by Statistics Sweden (SCB) and is for a cross-sectional population sample for 2001. The sample is restricted to native[14] men in the age group 28-36 who have taken the Swedish Military Enlistment test[15]. Individuals who studied during any part of 2001 are excluded.

Since we lack wage data for Sweden, we restrict the sample to individuals who were employed in the third week of November and who had an annual income from work above SEK 80,000 (about $11,500). These restrictions are expected to give estimates that come closer to the ones when using hourly wages[16]. For Sweden the sample consists of 291,055 males.

The respondents in the NSLY were in 1980 administered the Armed Forces Vocational Aptitude Battery (ASVAB), which consisted of 10 achievement tests. The AFQT consists of the four maths and verbal tests: Word Knowledge, Paragraph Comprehension, Arithmetic Reasoning, and Mathematics Knowledge. Following Hansen et al. (2004), we use the sum of these tests instead of the AFQT.

The Swedish test (Enlistment Battery 80), includes four separate tests: Instructions, Synonyms, Metal Folding, and Technical Comprehension. As with the AFQT, we use the sum of the four test scores[17]. When there is information missing for one of the separate test scores, we use the average of the other test scores as a proxy for the missing score. For some individuals the separate test scores are missing. These individuals are excluded from the sample.

Studies show that the results of achievement tests are affected by both schooling and age, indicating that these tests not only measure inherited ability (Hansen et al., 2004;

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[14] A native is defined as a Swedish-born individual with two Swedish-born parents.

[15] Most of those who do not enlist in the military probably have legitimate health reasons.

[16] When estimating returns to schooling in register data from SCB, Antelius and Björklund (2000) have shown that when excluding observations with low incomes, hourly wages can be replaced by annual income.

[17] The enlistment test intends to measure the general intelligence factor, G, (see Caroll (1993) for more information about the G factor). Using the G factor or the sum of the test scores does not change the result of the study. In Nordin (2007) the G factor is used.

Neal and Johnson, 1996; Winship and Korenman, 1997). The joint causality between schooling and the test score could create endogeneity problems[18]. In this study, this might become a problem if the endogeneity varies over the test score distribution.

Since there are variations in age when taking the AFQT, we separately age adjust them before adding the test scores. In Sweden, almost everyone takes the test at the same age, and therefore we do not have to age adjust the Swedish test scores.

It is uncertain whether the variations in schooling level when taking the AFQT create problems for the analysis. Since we have information about the schooling level at the test date, we could schooling adjust the AFQT. There are some differences in schooling level when taking the Swedish enlistment test—essentially those who do not continue to high school have a lower education level. However, since we do not know their schooling level at the test date (only finished schooling level), the Swedish test score cannot be schooling adjusted. Based on this discrepancy and the view of Lang and Manoves (2006) – early adolescent education primarily affects the AFQT – we decide not to schooling adjust any of the test scores. Nordin (2007) and Nordin and Rooth (2009) analyse the problem in detail, concluding that differences in schooling level when taking the Swedish test do not create endogeneity problems.

We are in a first step of the analysis to use a continuous test score variable, but the results are best illuminated using a grouping of the test score variable. To perform the main analysis, we therefore divide the individuals into different test score groups. Since the sample of individuals in the NLSY data is rather small, we must keep the number of test score groups small, dividing the individuals into only four groups. Important findings tend to appear in especially the left tail of the test score distribution, and we therefore keep the groups in the tails smaller. The first group consists of the lowest 15 percent of the test score distribution. The second and third groups consist of those with 15 to 50 percent, and 50 to 85 percent test scores, respectively. The fourth group is the highest 15percent of the test score distribution.

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[18] Conditioning on an endogenous test score variable (Angrist and Kreuger, 1991) causes a negative bias in the causal return to schooling estimate. Since we do not aim at estimating the causal return, this is not seen as a problem for the analysis.

For the US, the years of schooling variable is the highest grade completed as of May 1, 1993. The Swedish years of schooling variable is constructed from SUN 2000, which is adjusted to fit the International Classification of Education (ISCED97). The US schooling variable goes from 7 years of schooling to 20 years of schooling, whereas the Swedish schooling variable contain years of schooling between 9 and 20 (except 19 years of schooling). The NLSY provides us with an hourly rate of pay variable for 1993, whereas for Sweden the earnings variable is a measure of annual income from work for the year 2001.

Tables 1 and 2 show the distribution of individuals with different education levels for each of the four test score groups. Table 1 is for the US and Table 2 is for Sweden. The mean education level is about 1.2 years of schooling higher in the US sample than in the Swedish sample. With low marginal costs in Sweden, theory predicts that mean years of schooling should be higher in Sweden compared to the US. However, since the number of places in higher education in Sweden was relatively low during the 1980s (the places more than doubled since then), the Swedish cohorts who started their academic education during the late 1980s or the early 1990s are relatively low educated. Also, high scoring individuals in the Swedish enlistment test choose a low education level more often than high scoring individuals in the US test.

<div align="center">**Table 1 and Table 2 about here**</div>

If the education investment decision was more weakly related to ability in Sweden, we would expect the variation in test score for each education level to be higher in Sweden than in the US. To test if this is the case, we compare the standard deviation of the standardised test score for each education level between the countries. In Figure 5, the standard deviation of the standardised test score for each education level is plotted separately for the countries. Figure 5 illustrates that the standard deviation of the standardised test score for low and high education levels is higher in Sweden than in the US. The average standard deviation is about 0.10 higher in Sweden, whereas the difference is about 0.29 for education levels nine and ten. For education levels 15 to 20, the standard deviation is about 0.13 higher in Sweden than in the US. For education levels 11 to 14, the standard deviation of the standardised test score is the same for both countries. However, the main picture reflects that the standard deviation is higher in

Sweden, which indicates that the link between ability and the education level is weaker in Sweden than in the US. Moreover, the relatively high standard deviations for the eleventh to the fourteens education levels might be an indication that there are individuals who would benefit from more education (alternatively less education), and credit constraints might prevent them from investing in higher education in the US[19].

Figure 5 about here

5. EMPIRICAL MODEL AND EMPIRICAL RESULTS

The familiar Mincer (1974) model is extended in order to allow that ability to affect the returns to education. With M test score groups, where $m \in [1,...,M]$, the following earning equation gives the return to education, β_m, for each of the M test score groups:

$$(3) \qquad \ln y = \sum_{m=1}^{4} \delta_m \alpha_m + \sum_{m=1}^{4} \delta_m \beta_m S + \rho_1 Exp + \rho_2 Exp^2 + \rho X + \varepsilon$$

Nine dummy variables, δ_m, indicate which test score group the individual belongs to. It is also necessary to let the intercept, α_m, vary with the test score group. *Exp* and *Exp²* are potential experience and potential experience squared[20]. This model is the best for illuminating returns to schooling differences between groups.

In Table 3, the empirical model is estimated separately for the US and Sweden[21]. For comparability between the countries, we estimate the model when using a standardised outcome variable (logarithmic wage for the US and logarithmic annual income for Sweden). Yet, before presenting the results using the grouped test score, column (1) (for Sweden) and column (4) (for the US) report the estimate when interacting the years of schooling variable with the continuous test score variable. These estimates show that the returns to schooling increase more with the test score in Sweden than in the US. Although significant for both countries, the size of the estimates show that the returns to schooling increase more with the test score in Sweden than in the US. However, since different interaction effects are hard to compare, the magnitude of the

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[19] With school intervention IV estimates then become high.

[20] Potential experience is exp = age - 7 - years of schooling in Sweden, and exp = age - 6 - years of schooling in the US.

[21] In Sweden, we use 81 indicator (Nutek's basis of division) variables to control for the labour market. For the US, we control for living in an urban area.

country-difference is still rather unclear. Therefore, the model in equation (1) better illuminates group-differences in the returns to schooling – particularly when we also consider family background – and whether there are country-differences in the same.

The (standardized) returns to schooling for the different test score groups are outlined in Figure 6. For Sweden, we find a strong positive association between the test score and the returns to schooling[22]. The returns to schooling for the different test score groups are all significantly different from each other.

<div align="center">**Table 3 about here**</div>

For the US, Figure 6 shows that the return to schooling for the least skilled is somewhat lower than the return to schooling for the other test score groups. The return to schooling for the first test score group is, however, not significantly different from the other estimates. The small US sample makes it difficult to ascertain whether there are differences between the countries. However, if the relationship is also similar for women it indicates that the result for US is correct. In Figure 6, where we also illuminate the result for US women, we find that the relationship is very similar (except that men seem to have a higher, 0.15, return on average) to the result of US men. Still, from Figure 6 it is not obvious that the relationship is weaker for the US, but when relaxing linearity in the next section it is more evident.

<div align="center">**Figure 6 about here**</div>

Unlike for higher education, the credit constraints for going to high school are weak in the US, and therefore almost 60% in the first test score group reach at least 12 years of schooling. Considering this fact, it seems plausible that there is a share of the lowest test score group who go to high school, although this level of education does not result in a substantial income premium.

5.1. *Relaxing linearity*

A nonlinear return to schooling and missing observations for some schooling-test score cells might result in wrong conclusions. By estimating a model specification where we use indicator variables for each schooling-test score pair, the slope (that is the return

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[22] Nordin (2007) shows that the relationship between the test score and returns to schooling is stable when controlling for a study programme, completing a degree and parental income.

to schooling) for different segments of the education system can be compared between the test score groups. This is done separately for the two countries. We illustrate the income premiums for the schooling-test score pairs in Figure 7 for the US and Figure 8 for Sweden[23].

Figure 7 and Figure 8 about here

The figures highlight the fact that the income premia to higher education (more than 12 years of schooling) differs more between the test score groups in Sweden than in the US. One could speculate that if the average return to schooling in Sweden were as high as in the US, the dispersion might be even larger.

Unfortunately, due to empty cells it is not possible to estimate the income premiums for high school (9 to 12 years of schooling) for the two highest test score groups in the US. However, by studying the case of Sweden where the return to high school is linear for the highest test score groups, it is reasonable to believe that the results for the US would not change if there were no empty cells.

The low return to schooling for the lowest test score group in the US is explained by a generally low return to high school. Since 50% belonging to the first test score group have invested in 12 years of schooling, the income of those with 12 years of schooling very much affects the average return to schooling estimate for the group. In Sweden, we find that the low return to schooling for those scoring the lowest on the Swedish Enlistment test is due to a low return to upper-secondary school and to higher education.

5.2. *The returns when also restricting on family background*

To further evaluate if credit constraint and price differences of higher education affects the relationship between returns to schooling and ability, we added family background to the analysis. By restricting the focus to either those with a higher educated father or those with a lower educated father, the predictions of the optimal schooling model changes. In a schooling system such as the US system, the model predicts that the

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[23] For Sweden the reference group has nine years of schooling and belongs to the lowest test score group. For the US the reference group has eight years of schooling and belongs to the lowest test score group. For the US, income premiums with a very large standard deviation (due to a small sample size) are not shown in the figure.

relationship between returns to schooling and ability increases for individuals with a certain socioeconomic background compared to the general population.

In Sweden, with no credit constraints the relationship between returns to schooling and ability should not change when restricting the analysis to a certain socioeconomic background. Thus, to some extent this is the genuine test of the hypothesis, in other words whether a schooling system with low credit constraints causes the ability-variation in the returns to the schooling.

<div align="center">**Figure 9 and Figure 10 about here**</div>

In Figure 9, for Sweden, and Figure 10, for the US, the relationship between returns to schooling and the test score groups are illustrated separately for those with a father with more than 12 years of schooling and for those with a father with 12 years of schooling or less. Due to the small US sample, we cannot divide the sample into a larger number of socioeconomic backgrounds[24].

Regardless of the father's educational level, we find that for Sweden the relationship between returns to schooling and the test score groups are similar. The increase in the returns to schooling with the test score might be a bit higher for those with a lower educated father. For the US, Table 10 illustrates that the relationship between the returns to schooling and the test score differ with the father's education level. For those with a father with 12 years of schooling or less, the returns to schooling increases with the test score. The returns to schooling is significantly higher for test score group four compared to test score groups one and two. However, for individuals with a father with more than 12 years of schooling, there is no clear pattern in the relationship between the returns to schooling and the test score, and there are no significant differences. Similar results are found when also increasing the sample size with women. The decrease in the returns to schooling by test score for those with a higher educated father might be due to diminishing marginal returns of the schooling level. That is, since the most gifted with the best family means choose only very high education levels (87 percent of those in the highest test score group have 16 years of schooling or more), the average returns to

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[24] For the US, 106 individuals are lost because of missing information about father's education level. For Sweden, we lack information with regard to a father's education for 12 percent of the individuals.

schooling within the group is low. Figure 7 indicates this is the case, in other words after 16 years of schooling the returns are relatively low.

Thus, the results seem to align with the predictions of the optimal schooling model. An additional test is to also consider African-Americans in the US, a group of individuals for which the MCs might be, on average, high. Figure 10 illustrates that the returns to schooling for African-Americans increase even more with the test score than for individuals with a lower educated father. Hence, this is further evidence indicating that our hypothesis is correct, that is that it is the schooling system that seems to cause the county-differences in the relationship between returns to schooling and the test score.

6. CONCLUSIONS

The relationship between returns to schooling and ability seems to differ between the US and Sweden. In Sweden, the return to schooling significantly increases with ability. Since there is no plausible reason why individual heterogeneity in return to education should differ between the countries – in other words that the distribution in obtaining productive education should differ between random populations – the differences in relationship must be due to either demand factors or the educational system. We claim that it is primarily the educational system that differs between the countries, and therefore this is the place to look for an explanation of the observed differences.

We argue that a relationship between returns to schooling and ability shows up when mainly low ability individuals invest in relatively high education levels, and therefore receive a low-income premium.

Features of the Swedish schooling system (low credit constraints and the system for admitting people to higher education) tend to lower the marginal costs of education for low ability individuals. This might result in an imperfect allocation of individuals going to higher education in Sweden. In the US, credit constraints and an ambitious process for admitting people to higher education effectively sort out education investments with a low rate of return to schooling. Therefore, the relationship between returns to schooling and ability does not appear in the US. The result is in line with the predictions of the optimal schooling model, which outlines that the returns to schooling increase with

ability when the relationship between ability and costs is weak. Moreover, since the returns to schooling in the US increase with the test score for individuals with a lower educated father (and for African-Americans), it indicates that our hypothesis is correct.

An alternative explanation might be that the result of the AFQT is endogenous and therefore not able to reveal the present relationship between ability and returns to schooling in the US. However, numerous studies have successfully used the AFQT as a proxy for cognitive ability, and to question the results of these studies would be controversial.

In both countries, the way the estimated income premiums vary with the education level (and over the ability distribution) corresponds with our hypothesis. A sign of this is that (not only for Sweden but also for the US) the average high school income premium is small for individuals in the lower part of the ability distribution. Thus, for some individuals it seems as if the return to high school is low. Since this is observed in both countries, and the obstacles to going to high school are few in both countries, the indication is that our explanation is correct. Hence, when the schooling system is the same, the relationship between returns to schooling and ability is the same.

On their own, the empirical results in this study are not sufficient evidence to prove that the schooling system affects the estimated returns to schooling and the relationship between ability and returns to schooling. However, the fact that the schooling system fundamentally differs between the countries may be an important part of the picture. The results here at least agree with such an explanation.

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Tables and figures
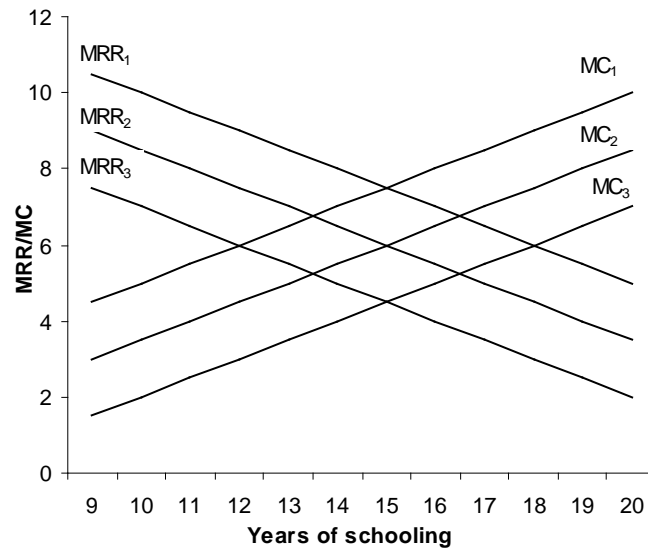
Figure 1. Illustrating different marginal rate of returns (MRR) to schooling and different marginal costs (MC) of schooling.
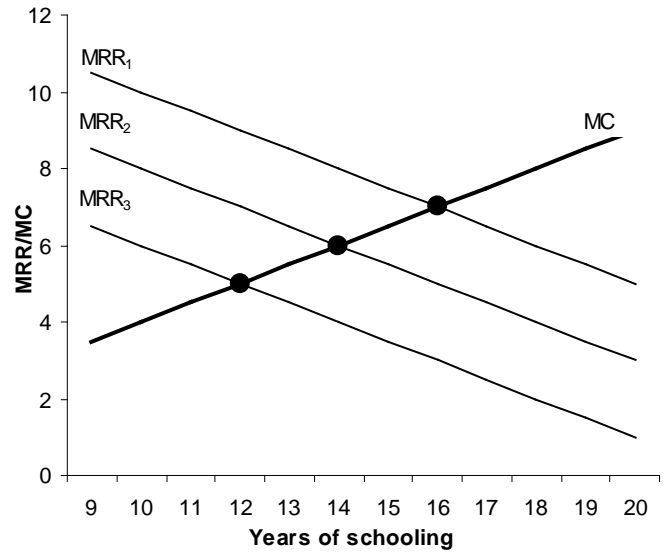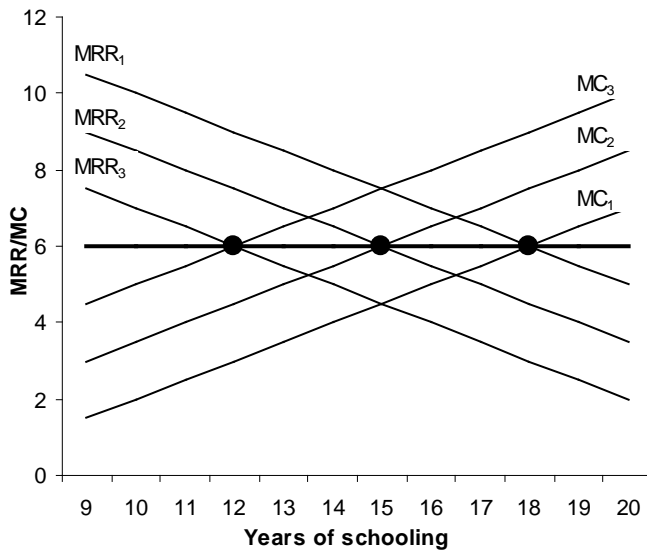
Figure 2 and Figure 3. Illustrating different solutions to the optimal schooling level problem.
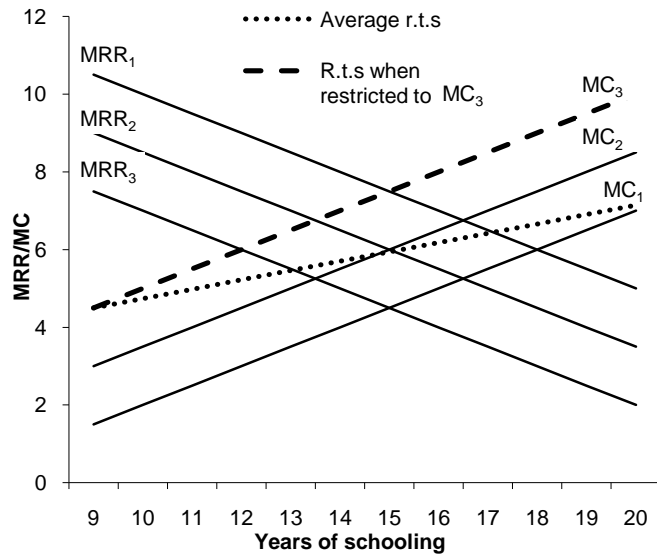
Figure 4. Illustrating the increase in the returns to schooling (r.t.s) by ability of the average population and for individuals with high MCs (when $0<corr(b,r)<1$).

TABLE 1.
NUMBER (AND PERCENT) OF INDIVIDUALS WITH A CERTAIN EDUCATION LEVEL FOR
EACH OF THE TEST SCORE GROUPS. US.

Education level	Test score group 1	2	3	4	Total
5	1				1
%	0,1%				0,1%
7	6	1			7
%	0,4%	0,1%			0,4%
8	24	4			28
%	1,4%	0,2%			1,7%
9	29	10	1		40
%	1,7%	0,6%	0,1%		2,4%
10	22	21	1		44
%	1,3%	1,2%	0,1%		2,6%
11	29	18	4		51
%	1,7%	1,1%	0,2%		3,0%
12	126	385	232	21	764
%	7,5%	22,8%	13,7%	1,2%	45,2%
13	11	47	52	8	118
%	0,7%	2,8%	3,1%	0,5%	7,0%
14	6	42	72	20	140
%	0,4%	2,5%	4,3%	1,2%	8,3%
15		8	29	10	47
%		0,5%	1,7%	0,6%	2,8%
16	1	45	140	97	283
%	0,1%	2,7%	8,3%	5,7%	16,7%
17		7	19	20	46
%		0,4%	1,1%	1,2%	2,7%
18		2	30	31	63
%		0,1%	1,8%	1,8%	3,7%
19			6	22	28
%			0,4%	1,3%	1,7%
20			4	26	30
%			0,2%	1,5%	1,8%
Total	255	590	590	255	1,690
Mean education level					13.36 (2.49)

Note: Five, seven or eight years corresponds to a compulsory education; nine to twelve years of schooling corresponds to a high school education; thirteen to sixteen years of schooling corresponds to an undergraduate education; and seventeen to twenty years of schooling corresponds to a graduate education level.

TABLE 2
NUMBER (AND PERCENT) OF INDIVIDUALS WITH A CERTAIN EDUCATION LEVEL FOR
EACH OF THE TEST SCORE GROUPS. SWEDEN.

| Education level | Test score group | | | | |
	1	2	3	4	Total
9	10,006	9,446	3,526	471	23,449
%	23.5%	9.4%	3.5%	1.0%	8.1%
10	2,031	2,256	935	138	5,360
%	4.8%	2.2%	0.9%	0.3%	1.8%
11	26,078	58,376	32,431	3,644	120,529
%	61.2%	58.1%	31.8%	7.9%	41.4%
12	3,382	16,361	19,869	5,438	45,050
%	7.9%	16.3%	19.5%	11.8%	15.5%
13	324	4,541	15,423	10,467	30,755
%	0.8%	4.5%	15.1%	22.8%	10.6%
14	451	3,788	8547	4,792	17,578
%	1.1%	3.8%	8.4%	10.4%	6.0%
15	268	4,047	12,157	7,380	23,852
%	0.6%	4.0%	11.9%	16.1%	8.2%
16	90	1,544	8073	11,156	20,863
%	0.2%	1.5%	7.9%	24.3%	7.2%
17	3	79	550	1,114	1,746
%	0.0%	0.1%	0.5%	2.4%	0.6%
18	1	17	101	287	406
%	0.0%	0.0%	0.1%	0.6%	0.1%
20	1	37	368	1,061	1,467
%	0.0%	0.0%	0.4%	2.3%	0.5%
Total	42,635	100,492	101,980	45,948	291,055
Mean education level					12.15 (1.99)

Note: Nine years of schooling corresponds to a compulsory education; ten to twelve years of schooling corresponds to an upper-secondary education; thirteen to seventeen years of schooling corresponds to an undergraduate education; and eighteen or twenty years of schooling corresponds to a graduate education level.
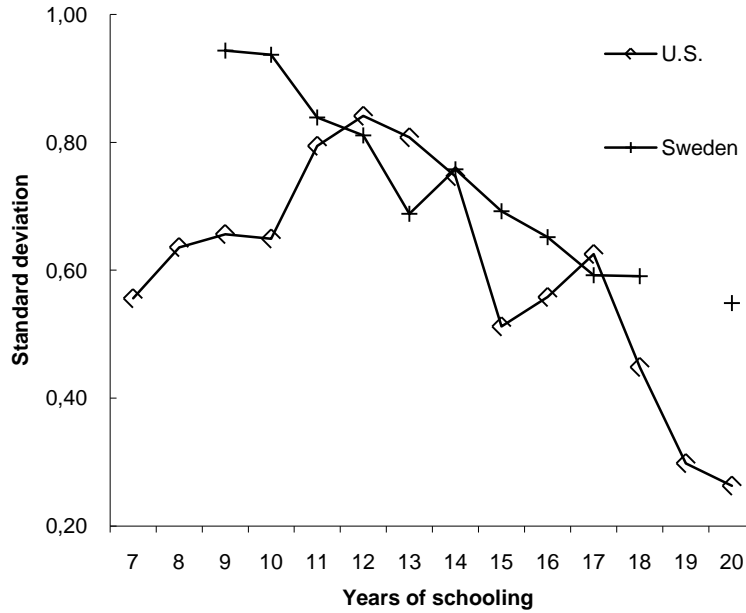
Figure 5. The standard deviation of the standardised test score for each education level, for the US and Sweden.

TABLE 3
RESULTS OF ESTIMATING THE RELATIONSHIP BETWEEN THE TEST SCORE AND RETURNS TO SCHOOLING.

	Sweden		US	
	(1)	(2)	(3)	(4)
Years of schooling	.150 (.001)***		.163 (.015)***	
Returns to Schooling for each TS				
Test score group 1		.083 (.004)***		.130 (.035)***
Test score group 2		.140 (.002)***		.175 (.025)***
Test score group 3		.185 (.002)***		.186 (.020)***
Test score group 4		.200 (.002)***		.197 (.028)***
Test Score	- .194 (.011)***		- .001 (.006)	
Years of schooling*TS	.031 (.001)***		.001 (.000)*	
Potential experience	.177 (.004)***	.180 (.004)***	.126 (.044)***	.128 (.044)***
Potential experience^2	-.005 (.000)***	-.005 (.000)***	-.003 (.002)	-.003 (.002)
Test score group 1		.442 (.048)***		.234 (.472)
Test score group 3		-.365 (.030)***		.035 (.380)
Test score group 4		-.394 (.038)***		.043 (.519)
Constant	-3.024 (.030)***	11.360 (.014)***	-3.569 (.397)***	-3.793 (.460)***
Observations	291,055	291,055	1,690	1,690
R-squared	.209	.206	0.26	0.25

Notes: For Sweden, the dependent variable is logarithmic annual income from work. For the US, the dependent variable is logarithmic hourly wage. The dependent variables are standardised (subtracting the mean and dividing by the standard error). For Sweden, we control for labour market region. For the US, we control for living in an urban area. Standard errors in parenthesis.
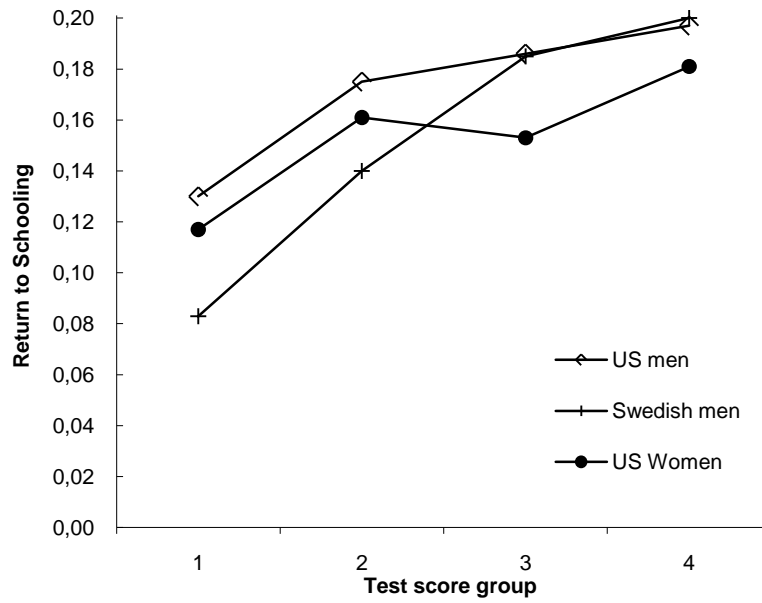
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Figure 6. Illustrating the relationship between the test score and returns to schooling.
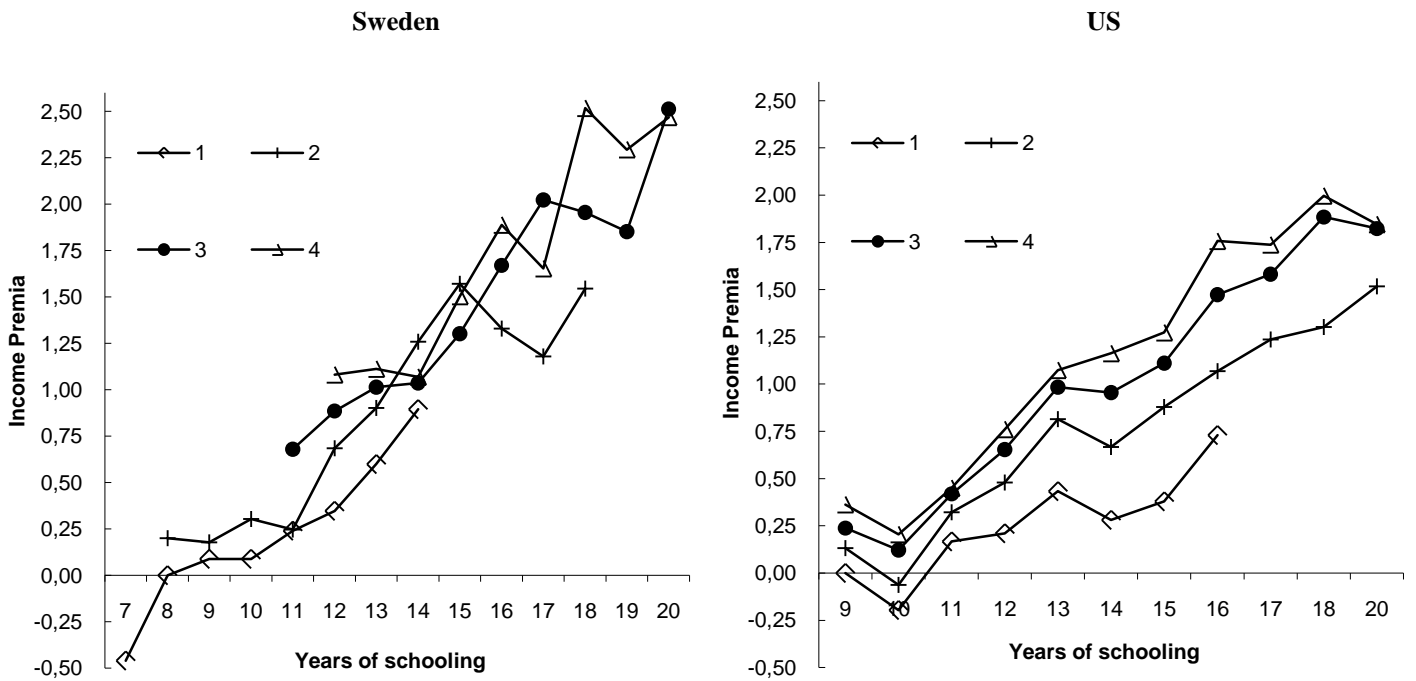

Figure 7 and 8. Estimated income premiums for the schooling-test score pairs (when using a standardised outcome).
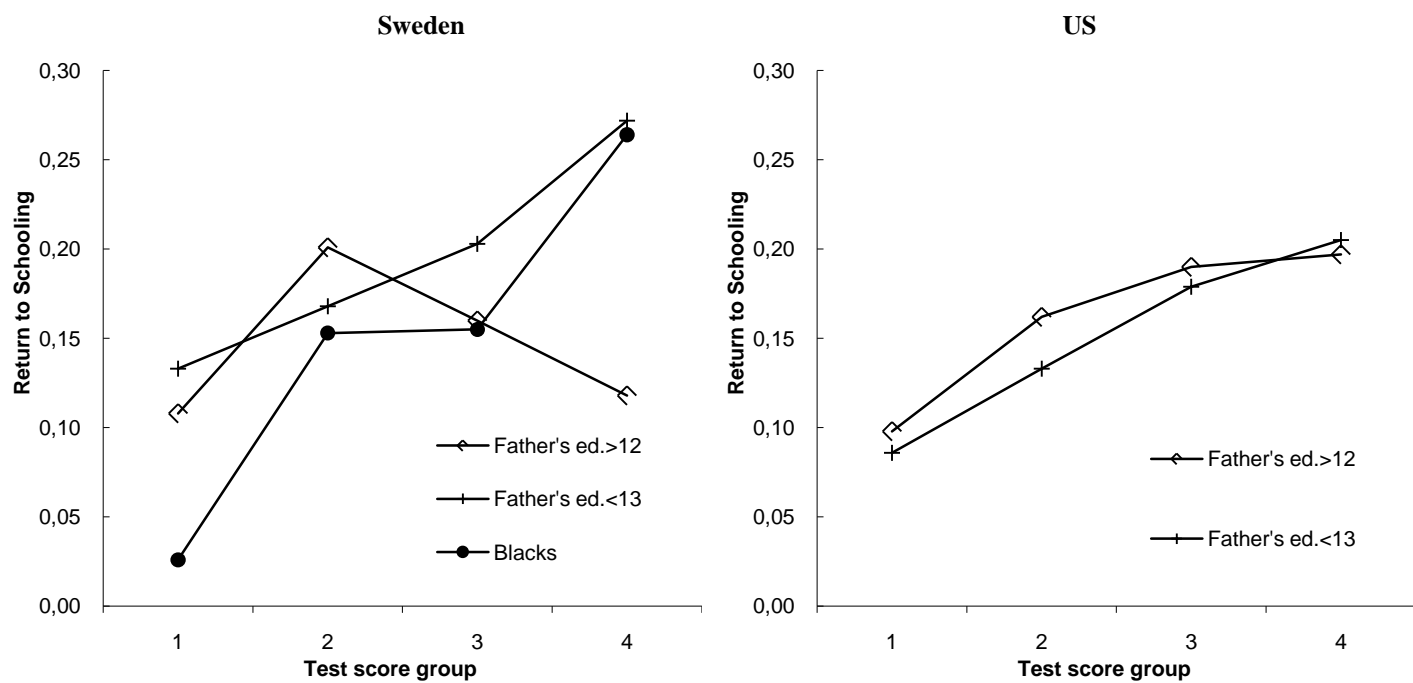
Figure 9 and 10. Illustrating the relationship between the test score and returns to schooling for different groups of individuals.