One size fits all?

The effects of teacher cognitive and social abilities on student achievement

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Abstract

We document a substantial decline in the cognitive and social interactive abilities of new teachers. Using matched student-teacher data we then estimate the causal impact of teachers' abilities on student achievement. Teachers' abilities have a negligible impact on average student achievement but this hides important heterogeneities: An increase in teachers' social (cognitive) abilities reduce (increase) the achievement gap between high and low aptitude students. We also find strong positive effects of male teachers' own GPA, uniform across students, but not for female teachers. These heterogeneities highlight the potential for policies aimed at student-teacher matching, and gender specific selection into teaching.

Keywords: Cognitive and social ability, Teacher quality, Student achievement

JEL-codes: I21, H4, J4

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1 Introduction

Hardly anyone involved in education would deny the importance of teacher quality for student performance. Indeed, there is a large body of research showing that “teacher fixed effects” are systematically related to student outcomes. With the exception of teacher experience however, it has proven remarkably difficult to pinpoint observable teacher characteristics that raise student achievement (e.g. Rockoff, 2004 and Rivkin et al., 2005). A conjecture has been that the position of teachers in some general, but hard to observe, ability distribution is what matters for student outcomes. The worry about teacher quality has therefore been fuelled by studies from several countries showing that the abilities, gauged by aptitude tests or standardised subject tests, of new teachers and individuals entering teacher education have declined substantially over time.[1] Despite widespread beliefs to the opposite (McKinsey, 2007 and *Economist*, 2007), however, a causal link between such general abilities of teachers and student achievement has largely been assumed rather than shown.[2]

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[1] See Nickell and Quintini (2002) for the UK; Corcoran et al. (2004) and Bacalod (2007) for the US; Leigh and Ryan (2006) for Australia; Fredriksson and Öckert (2008) for Sweden. Hoxby and Leigh (2004) and Lakdawalla (2006) are other studies documenting the decline of teacher aptitude and ability in the US. These studies are all based on ability measures that are (more or less) comparable across cohorts. Importantly, ability is measured prior to the start of teacher education so they do not reflect the impact of the educational and professional choices themselves. While the mentioned studies attempt to explain the decline in teacher ability, this issue is beyond the scope of our paper.

[2] See Wayne and Youngs (2003) and Hanushek and Rivkin (2006) for surveys of this extensive literature. Several papers use the selectivity of teachers’ undergraduate institution as a proxy for the position in the ability distribution. This is at best a crude measure of individual ability that may also reflect the quality of the education that the teacher has received. Other studies find that the scores on teacher licensure tests affect student outcomes, but this again has little to say about the teacher’s position in the general ability distribution. Ehrenberg and Brewer (1995) find a “verbal ability test” to be positively related to student outcomes, but the measure is aggregated to the school level and its relation to the general ability distribution is unclear. Ferguson and Ladd (1996) find a positive relation between college entrance ACT scores and student

In this study, we first document a substantial decline in abilities among entering teachers. To this purpose, we use measures of cognitive and social interactive abilities from military enlistment, covering essentially the entire male population. The cognitive evaluation is close to a standard IQ-test and the social ability evaluation is aimed at capturing a wide range of personality traits related to the capacity to exhort group cohesion.[3] As the draft data are available only for men, we also make use the upper-secondary grade-point average (GPA) of entering teachers.

We then use a large dataset matching teachers and students in the last year of the Swedish middle school, which allows us to take advantage of the within-student across subject variation to estimate the impact of teachers' abilities on how well students perform on national standardized tests. In that respect our empirical strategy is close to for example Dee (2005), Dee and West (2011), Lavy, Silva and Weinhardt (2012), Clotfelter, Ladd and Vigdor (2010), and Bandiera et al. (2010). The identification strategy builds on the assumption that student-teacher matching is not based on subject-specific student ability, and is well suited for the present setting since subject-specific ability tracking is not allowed in the Swedish middle school. By relating an indicator for such subject-specific student abilities, based on parental educational choices, to teacher abilities, we cannot reject this identifying assumption. Moreover, the identification also depends on teachers not being differently selected to subjects based on some unobservable skill, and that the production technology does not differ across subjects. We find no evidence (i) that the correlation between cognitive and social skills differs by subject, (ii) that the correlation between cognitive and social skills to a third

achievement gains among 3 and 4 graders. The ACT is, however, taken by an already selected group of individuals. Close to our study is also Hanushek (1992) who finds that gains in reading performance among 2-6 graders are greater if the teacher has scored high on the "Quick word test", sometimes seen as a substitute intelligence test.

[3] Lindqvist and Vestman (2011) find both the cognitive and non-cognitive evaluations to be strong predictors of future labor market success.

productive characteristic (body-mass-index) differs by subject,[4] (iii) that the correlation between cognitive and social skills differs by subject for male and female teachers' full brothers. Further, we find no indication that the relationship between social skills and student outcomes varies by subject. However, we do find indications that this relation differs for cognitive skills. The results for cognitive skills should therefore be interpreted with caution.

Our results suggest that teacher cognitive and social interactive abilities have a negligible impact on average student achievement. This result, however, hides important heterogeneities between different students and between male and female teachers. An increase in (male) teachers' cognitive abilities tends to increase the achievement gap between high and low aptitude students. An increase in social interactive ability on the other hand tends to benefit students in the lower end of the achievement distribution. Teachers with high social abilities appear to be particularly beneficial to the achievement of students with an immigrant background. We further find strong positive effects of male teachers' own upper-secondary GPA: a one standard deviation increase in their GPA yields a 0.13 standard deviation increase in student achievement. While this effect is relatively uniform across student groups, no similar positive effect of having a high GPA is found among female teachers. This asymmetry between male and female teachers does not appear to be due to gender specific selection into teaching.

Social interactive abilities have been found to be important in other professions and our paper is among the first demonstrating their importance among teachers. There is a large literature in educational psychology stressing the importance of student-teacher interactions in shaping student motivation, in particular among students who are academically at risk (Roorda et al, 2011). The capacity to develop good teacher-student relations is also central to classroom management which in turn is a powerful predictor of student achievement

[4] See Lundborg et al (2010) for an analysis of the relation between body mass index and labor market outcomes.

(Cornelius-White, 2007). As the evidence suggest that classroom disruptions and negative peer effects have the strongest negative effects on low-achieving students (Lavy et al, 2011), our results square well with the insights from this literature.

Our findings are broadly in line with previous findings in the literature. Rockoff et al (2011) find statistically significant effects on student achievement by composite measures of cognitive and non-cognitive abilities. The size of these effects is modest however; a one standard deviation increase in teacher ability results in a 0.025 standard deviation achievement gain. Unfortunately the authors do not differentiate between male and female teachers or between different groups of students. Our findings regarding the heterogeneous effects by the same teacher ability on different student groups correspond well with Clotfelter et al. (2006) who document that the positive impact of teachers' mathematical abilities is concentrated among high achieving students. Our results highlight the importance of student-teacher matching. This is consistent with Jackson (2013) who finds that the quality of the match between teachers and students is as important as teacher quality per se. Hence our results suggest a scope for policies towards a more coordinated student-teacher matching as well as gender specific selection into teaching.

In what follows, we start by describing the different ability measures and document the decline in teacher abilities along these dimensions. We then discuss our identification strategy in the light of the institutional features of the Swedish school system and data. Thereafter we present our results, and in the final section we conclude and discuss policy implications of our findings.

2 The evolution of teacher abilities

Evidence from several countries cited in the Introduction shows that the general abilities of teachers are declining over time. In this section, we present three different ability measures and then describe the decline in these abilities among entering teachers in Sweden.

2.1 Ability measures

In order to track the abilities of teachers according to some general characteristics, it is necessary to use ability data based on large representative samples of the population. We have access to three such measures. The first is a measure of cognitive abilities from the military draft, available for essentially all Swedish men. The second, also from the military draft, is an evaluation of social interactive ability. Both these ability measures are strongly related to future earnings (Lindqvist and Vestman, 2011). Finally, we have information on upper-secondary school GPA for both men and women. The GPA captures a mix of cognitive and non-cognitive abilities and has been shown to be good predictor of future earnings, even after controlling for cognitive ability (Björklund et al, 2005; Lindahl, 2001). The main benefit of the draft data is that the tests are designed for capturing particular cognitive and social capacities. The main drawback is that these data are only available for men.

During the years we study, all Swedish men were by law obliged to go through the military draft, when called upon. In most cases, the draft occurs the year the man turns 18. Up until the late 1990s, more than 90 percent of all men in each cohort went through the whole draft procedure. The draft consisted of a series of physical, psychological, and intellectual evaluations. For the purpose of this study, we have acquired data on the draft tests of cognitive ability and on the standardised psychological evaluation of social interactive ability under war-time stress. Comparable data are available from 1969 to 1999, which means that our data contains information for conscripts born approximately between 1951 and 1977.

Both the cognitive and social interactive ability is measured form 1-9 on a stanine scale; ie a on discrete normally distributed 1-9 scale with standard deviation 2. By using the stanine scale the Swedish military makes the assumption that both cognitive and social interactive ability is evenly (and normally) distributed around the mean.

The evaluation of cognitive ability consists of several subtests of logical, verbal, and spatial abilities, as well as a test of the draftees' technical understanding. The results on these subtests are combined to produce a general cognitive ability ranking on a 1-9 stanine scale. The cognitive test has been subject to evaluation by psychologists and appears be a good measure of general intelligence (Carlstedt, 2000). In order to account for general trends in test-taking capacity and for minor changes in the draft tests, we standardize the measure (mean zero, standard deviation one) by draft year.

The other measure from the military draft is a psychological evaluation of the draftee's personality traits: we call this measure *social interactive ability*. The evaluation is performed by a certified psychologist who conducts a structured interview, aiming to determine the draftee's psychological capacity for military service. In particular, the aim is to capture the draftees capacity to exhort group cohesion. The draftee's personality is scored along four domains (Mood et al, 2012): social maturity (extroversion, having friends, taking responsibility, independence); psychological energy (perseverance, ability to fulfil plans, to remain focused); intensity (the capacity to activate oneself without external pressure, the intensity and frequency of free-time activities); emotional stability (the ability to control and channel nervousness, tolerance of stress, and disposition to anxiety). It should be noted that motivation for doing the military service was explicitly not a factor to be evaluated. Grades were given on four different sub-scales, which were transformed by the enlistment agency to a discrete variable of non-cognitive ability ranging from 1 to 9 on a stanine scale, which we standardize by enlistment year. To a large extent, the psychological evaluation captures the same personality traits that make up the Big Five domains of personality (Bouchard, 1994), but they are grouped together somewhat differently.

The final measure of teachers' ability is their upper-secondary school grade point average, GPA, generally determined the year a student turns 18 or 19. The GPA is a very general ability measure capturing not only cognitive abilities, but also personality traits like adaptability, ambition, motivation, maturity and conscientiousness. It should be noted that the GPA in Sweden is an important instrument for selecting students for post-secondary education. GPA data from the upper-secondary school is available from the cohort graduating in 1985 and onwards; that is, those born approximately 1966 and later. We standardize the GPA scores for each cohort of graduates, thereby taking potential grade inflation into account.[5]

To sum up, we use three different measures of abilities—cognitive ability, social interactive ability, and upper-secondary school GPA—all measured at about same age. Since all abilities are measured prior to entering tertiary education, they are not affected by subsequent educational attainment. The measures are all related but still capturing different aspects of individual capacities: the correlation between social interactive and cognitive ability is 0.39, which is close to the correlation between cognitive and non-cognitive personality factors reported by Cunha and Heckman (2008). The correlation between GPA and cognitive ability is 0.49, and 0.28 between GPA and social interactive ability. If we regress the GPA on social and cognitive abilities, both variables are highly significant and

[5] In upper-secondary school there are different programs, and grading standards may differ between programs. However, since most teachers have graduated from three year theoretical programs we believe any differences in grading standards to be a negligible problem. Still, in all analyses using the GPA measure we control for upper-secondary school program. Further, in 1992 there was a minor change in the grading system as it was no longer possible to exclude the two lowest grades from the GPA when applying to higher education and in 1996 there was also a change as the system of relative grades was replaced with goal related grades.

together they pick up 25 percent of the total variation in GPA.[6] This indicates that a substantial part of the variation in GPA is captured by the cognitive and non-cognitive skills. Further, the Swedish upper-secondary GPA has been shown to be a better predictor of academic achievement than the Swedish SAT equivalent test (Björklund et al, 2010; Cliffordson, 2008).

2.2 The evolution of the teacher pool

In Sweden, all teachers are registered in the *Teacher register* from 1979 onwards. We match our ability measures to this register and track entering teachers according to their cognitive and social interactive abilities from 1980 and onwards. For teacher GPA this is possible from 1993 and onwards. As abilities are measured prior to entering tertiary education they are unaffected by any changes in the quality of teacher education that may have occurred over time.

The ideal way to measure the evolution of abilities in the teacher pool would be to track the average ability scores of the entire teacher stock over time. However, with the teacher register being available from 1979 and the draft data only being available between 1969 and 1999 this is not possible. As draftees are around 18 years old, these abilities are only observed for teachers aged 29 and younger in 1980. Hence, the available draft data does not allow us to paint a comparable picture of the teacher stock over time. For this reason we instead track the average annual values of cognitive and social interactive abilities for teachers aged 25 to 30 *entering* the teacher register. Similarly, abilities based on the GPA are available for entering

[6] In this regression the coefficient (standard error) for cognitive ability is 0.47 (0.001) and 0.14 (0.001) for social ability. The number of observations in this regression is 596,143.

teachers aged 25 to 30 between 1993 and 2006. We restrict our attention to teachers in theoretical subjects, so called subject teachers.[7]

[Figure 1]

The evolution of cognitive ability, social interactive ability, and GPA among new subject teachers in the Swedish middle school system is depicted in *Figure 1*. There has been a marked decline in all ability measures, most pronounced in cognitive ability. According to the cognitive draft test, the average ability has declined by approximately 0.5 standard deviations since the peak in the early 1990's. The decline in social ability is about 0.4 standard deviations and in GPA 0.35 standard deviations. The decline in GPA is of similar magnitude for both men and women, although female teachers on average tend to have a higher GPA throughout the period. The observed patterns are not sensitive to the age restrictions imposed. In Sweden, students usually graduate from secondary education the year they turn 19. Becoming a subject teacher takes approximately 4.5 years and gap years are common in Sweden.[8] When analyzing the age groups 25-35 and 23-30 rather than 25-30 year olds, the trends are essentially the same.[9]

The fact that the rate of decline in GPA is similar for men and women suggest that there are no important gender differences in ability trends among teachers. In order to get a more complete picture of gender differences in the decline, we regress the average ability of the full brothers of male and female teachers on a linear time trend, thus utilizing that the sibling

[7] This means that we do not include teachers in athletics, aesthetics, music, home economics, shop, and similar subjects. The main reason for this exclusion is that we estimate student outcomes only on theoretical subjects. Further, the turnover of non-theoretical subjects in the curriculum is much higher that in the core subjects. By excluding the practical subjects we thus increase the comparability of the teacher pool over time.

[8] According to Statistics Sweden (2013), less than 20 percent of all students made a direct transition from secondary to post-secondary education during the years 1993/94-2005/06.

[9] These results are available upon request.

component in cognitive and social abilities is strong (See Grönqvist et al, 2010 for details). Under the assumption that ability correlations between siblings have not changed over time, this approach is informative of the trends in cognitive and social abilities for female teachers relative to that of male teachers. In columns 1 and 2 in Appendix *Table A1*, we see that the trends in cognitive ability are similar among brothers of male and female teachers. The trend coefficient is larger (in absolute values) for women, albeit not statistically different from the male trend. For social interactive ability in columns 3 and 4, we find a statistically significant negative trend for female teachers and an insignificant trend for males. Again, the difference between these trends is not statistically significant.[10] This is in line with the findings in Bacolod (2007) who shows that the decline in teacher abilities in the US has been much more pronounced among women than among men. Corroborating evidence for Sweden can be found in Fredriksson and Öckert (2007) who, using an alternative measure of cognitive ability, find that the decline among those graduating from teacher collage has been slightly larger for women.

To sum up, the results show that the decline in teacher abilities has been rapid and large in Sweden. The purpose of this paper is not to analyse the reasons behind these developments but both demand and supply factors are likely to have played a role. As discussed in Fredriksson and Öckert (2007), the relative payoff to entering teaching has declined substantially since the mid 1980's and the same applies to the returns to cognitive abilities among teachers. There has also been a large increase in the demand for teachers and between 1997 and 2003 the number of teachers increased by approximately 15 percent. This increase

[10] In Grönqvist et al (2010) we find that the brother correlation in cognitive ability is 0.45 and in social ability 0.3. By dividing the coefficients in columns (6) and (7) by these correlations we get an implicit Wald estimator. For cognitive abilities, this Wald estimate is close to identical to the coefficient in column (1). For social ability, however, the Wald estimate is smaller than the corresponding coefficient in column (2).

was both due to an increase in the number of students and increases in the teacher-student ratio.[11] Numerous reforms have taken place in the Swedish school system since the early 1990's. Among the most significant was a radical decentralization: From having been one of the most centralized in the world, municipalities took over the responsibility from the central government and a universal voucher system was introduced. A new curriculum that downplayed subject content in favor of other student (and teacher) competences was introduced in the years following 1994. Teacher education underwent several reforms from 1985 and onwards. Isolating the impact of these – and other – reforms is a very challenging empirical task.

3 The school system and empirical strategy

To estimate causal effects of teacher characteristics on student performance, teachers with different abilities would ideally be randomly assigned to students. In our setting, this is not the case. Rather, students and teachers are sorted into schools and classes in non-random ways that would bias the results unless the selection process is properly addressed.[12] In this section, we provide a brief introduction to the Swedish school system and then describe our identification strategy in light of these institutional features.

[11] These are official numbers downloaded from the database *Jämförelsetal* (http://www.jmftal.artisan.se/default.aspx), maintained by The National School Board. The series are "Number of full time equivalent teachers" ("Lärare, antal heltidtjänster") and "Full time equivalent teachers per 100 students" ("Lärare (heltidstj.), antal per 100 elever").

[12] Clotfelter et al. (2006) documents this type of sorting between and within schools in the North Carolina elementary school system, and discuss the biases that arise when not taking sorting into account.

3.1 The Swedish school system

Compulsory education in Sweden usually starts at age seven and lasts for nine years. Thereafter, a non-compulsory three year upper-secondary program follows. The municipalities are responsible for all tiers of schooling. The 1985 *Education Act* (Ministry of Education and Research, 2000) sets the national educational standards which are overseen by the Swedish National Agency of Education. The middle school system is organized around municipal schools that all students within a municipality formally are free to apply to. Actual admittance is in practice highly regulated as priority has to be given to students residing within the school's catchments area.[13] Schools, at the compulsory level, are not allowed to screen students based on their academic merits. The *Education Act* provides detailed requirements that all schools have to fulfil, leaving schools with limited discretion in influencing the curriculum.[14]

In order to measure student achievement, we use the results from nation-wide standardized tests in Swedish, English and Mathematics, taken during the last year of middle school (grade 9). These tests are used to aid the teacher when setting students' final grades (Skolverket 2004). The middle school grades are used to sort students when applying for upper-secondary school.

3.2 Identification

There is substantial sorting of students between Swedish middle schools, reflecting the socio-economic situation in different residential areas. Within schools there may also be sorting, mainly in the sense that students from different residential locations are not randomly

[13] Since 1992, Sweden also has a comprehensive voucher school system described in Björklund et al. (2005). As we are only dealing with municipal schools in this study, the voucher schools will not be discussed further. It should be noted that the *Education Act* regulates private as well as the public schools.

[14] Out of 6,665 compulsory school hours, the schools are free to decide on less than 10 percent; 600 hours (Skolverket, 2007).

assigned to different classes. Schools have varying policies in this regard, but the typical feature is that students living close to each other are grouped together. In addition, it should be stressed that ability tracking is not allowed in compulsory schools.[15] Thus, while students are definitely sorted in Swedish middle schools, sorting mainly occurs along the lines of general ability and motivation based on socioeconomic background, and not due to subject-specific student proficiency. As teachers are likely to be matched to students in non-random ways based on these general characteristics, we need to control for average student ability.

Each middle school student is observed across several subjects, but only once for each of these. This allows us to use an empirical strategy—used by for example Dee (2005), Dee and West (2011), Lavy et al. (2012), Clotfelter et al. (2010), and Bandiera et al. (2010)—holding general student ability constant by controlling for student fixed effects. As middle school students are primarily sorted on general ability, this approach ensures that teacher ability is uncorrelated to students' subject-specific skills. Further, there may be a correlation between the relative difficulty of a subject and teacher ability. If, for example, teachers in mathematics on average have a high ability while it is difficult to achieve a high test result in this subject, our ability estimates will be downward biased. We control for this by including subject fixed effects. Hence, we estimate the following relationship:

$$Test\ score_{its} = a\ Teacher\ Ability_t + X_t'b + \mu_i + \mu_s + \varepsilon_{its}.$$

The outcome is the standardized test score for student *i*, in subject *s*, taught by teacher *t*. We are primarily interested in estimating the parameter *a*, the impact of teacher ability on student achievement. Other teacher characteristics—birth cohort indicators and, where applicable, a gender indicator—are captured by the vector X_t,[16] and μ_i are student fixed

[15] In Sweden, ability tracking was gradually abandoned with the introduction of the new middle school curriculum, Lpo94, in 1995 (Skolverket, 2006). As of 1998 tracking was completely abolished.

[16] We use biennial cohort indicators since there are very few teachers in some of the cells when using annual indicators.

effects. Finally, μ_s are time-specific subject effects that take differences across subjects into account. The birth cohort indicators deal with any trends in test taking capacity, such as the Flynn (1984) effect changes in teacher education, that may have occurred over time, as well as potential changes in the motivation to become a teacher based on unobservable characteristics. Standard errors are clustered by teacher.

We are interested in estimating the full impact of teacher abilities on student achievement. As both the educational attainment of teachers and their experience level are likely to be endogenous to ability, we only include controls for birth cohort and gender indicators in our regressions. The approach to exclude variables such as educational attainment is standard when estimating the full effect of personality factors such as IQ on earnings (e.g. Neal and Johnson, 1996). There is also little variation in the educational background among subject teachers.

Under the assumption that students are assigned teachers based on the same mechanism across all subjects, this within-student across-subject estimator captures the causal effect of teacher characteristics. The strategy is related to a value-added approach (Rockoff, 2004; Hanushek and Rivkin, 2006) in that we control for average student performance across subjects. Note that the within-student estimator does not demand that students have the same proficiency in all subjects. In order to appreciate the within-student estimator, it is useful to consider the situations in which it would not yield unbiased estimates on teacher characteristics. For this to occur it needs to be the case that students, within a school, are assigned to teachers in a way that teachers' characteristics are correlated to students' subject specific skills; for example if students that are good in Math but are bad in Swedish and English have a high ability Math teacher and low-ability language teachers. While this can certainly be the case in individual schools, it is unlikely to be a general scenario especially considering that tracking is illegal in Swedish compulsory schools and that compulsory schools are not allowed to admit students on academic merits. Subject specific proficiency would thus balance out. We will present evidence suggesting that sorting based on subject specific ability is not related to teacher cognitive and social ability.

Two other threats to the identification strategy is i) that the selection into teaching may differs across subjects—meaning that measured skills convey different information concerning unobserved skills in different subjects—and ii) that the production technology may differ across subjects. While differential selection is a worry that we share with all papers trying to assess the importance of teacher traits—as selection may vary across different contexts—we here explicitly test whether the selection into teaching differs by subject or gender. We will also assess if the impact of teacher abilities differs between subjects. A drawback of these tests is that the number of, especially male teachers, is low in some dimensions.

4 Data

To estimate the effect of teacher abilities on student achievement, we use detailed data matching individual students to individual teachers. These data are linked to teacher abilities based on upper-secondary school GPA and on the cognitive and social interactive ability scores from the military draft, as described in section 2. Such a linkage is possible since all Swedish residents have a unique personal identifier that follows them throughout life.. In this section we describe the data coming from different sources and how the data set is compiled. Note that the age restrictions needed when estimating trends among entering teachers serve no purpose when estimating the impact of teacher abilities. The data set therefore covers all teachers for whom we have access to ability data.

4.1 Schooling data

In Sweden, there is no central authority keeping records that allows the individual grade setting teacher to be matched with the individual student. Some municipalities have computerized student records allowing such a link to be created. We have been able to acquire data linking teachers and students from nine of the largest municipalities in Sweden, covering roughly 20 percent of all Swedish compulsory school students in each cohort. These schooling data are available for the years 2003 to 2007 and the coverage varies between municipalities.[17]

The data files for the compulsory schools contain information on test scores from national standardized tests in Swedish, English, and Mathematics, taken during the last year of compulsory schooling (grade 9). Test results are standardized to mean zero and standard deviation one by year. One caveat has to be mentioned. Usually, the same subject teacher is responsible for a subject throughout middle school. However, due to parental leave among teachers, teacher and student mobility, retirement and so on, there is some turnover in the student-teacher match. As no records are kept prior to the final year of compulsory school, we have no way of determining how many years students and teachers have actually been matched.

4.2 Individual level data

In order to undertake an analysis of asymmetric effects across different student groups we add student background information to our dataset. These data are from Statistics Sweden's population wide register datasets – based on tax records and population censes – where we

[17] We contacted the 20 largest municipalities—in terms of compulsory school students—with a request for data matching students with grade setting teachers. Of these, nine had computer systems that made it possible to fully meet this request: Stockholm, Göteborg, Malmö, Uppsala, Jönköping, Örebro, Västerås, Linköping and Halmstad. The reason for contacting the largest municipalities was that the data request was both time-consuming and expensive.

have acquired information on student gender and immigration status. From these records we also collect information on teacher age and gender. A student is classified has having a *foreign background* if he or she is either born abroad or if both parents are born abroad.

4.3 The matched data set

The base for the analysis is schooling data between 2003 and 2007 from nine municipalities containing information on individual test scores for each student and the identity of the subject teacher.

Since teachers are recorded using their unique personal identifier, they can be matched both to their upper-secondary school GPA and their draft records. The GPA data are available for teachers graduating from upper-secondary school in 1985 and later. Draft data, in turn, are available for the draft cohorts 1969 to 1999 and made available by the National Service Administration and the Swedish War Archive. This means that only male teachers born from 1951 to 1977 who were Swedish citizens at the time of the draft can be matched to the schooling data. Even if the draft data is available for a longer period we have more observations in the GPA data; when using the draft data where only men are available we lose approximately two thirds of all grade setting teachers compared to the original data.[18] This also reduces the number of observations per students, relative the GPA data.

In total, we have 1,603 (740) teachers for whom we observe their GPA (draft record), administering 71,903 (31,502) test scores to 46,472 (26,192) students. Summary statistics of the data is shown in *Table 1*.[19]

[18] This also means that the group of teachers we analyze is relatively homogenous, which is an advantage since we want to isolate the effects of ability differences.

[19] As can be seen, the mean values for the standardized outcomes are not exactly zero. The reason is that we are using two different, only partly overlapping, samples. We have therefore standardized outcomes using the whole population of students, prior to matching teachers and students.

[Table 1]

In the GPA-sample of teachers, 69 percent are female, the average age is 33 and the average high school GPA score is 0.43. In the draft sample, the average age is close to 39 and the cognitive score 0.75. The mean score in social interactive ability is 0.41. Student characteristics vary little between the GPA and draft samples: 12 percent of students have two parents with post-secondary education, 21 percent have a foreign background, and 49 percent of the students are female.

As our identification approach is quite data intensive, we also present summary statistics for the samples of students and teachers that are actually used for identification. Out of a total of 46,472 (26,192) students in the GPA (draft) sample, effects are identified using 16,644 (3,154) students. Out of the 1,603 (740) teachers, 1,181 (272) are used for identification in the respective samples. The main difference between samples is that students in the identifying samples are somewhat overachieving compared to students in the non-identifying sample. Teacher characteristics do not differ significantly between samples. In *Table A2* in the Appendix we present teacher characteristics by samples and subjects. The only significant difference between the identifying and non-identifying samples is that non-identifying teachers in Swedish have higher social ability than identifying teachers in this subject. Furthermore, teachers in math have higher cognitive skills than teachers in English and Swedish. Despite this, teachers in math have lower GPA than English and Swedish teachers, which to a large extent is due to the higher representation of male teachers in math. In *Figure A1* in the Appendix we display the distribution of student test scores by subject.

Since we use the within-student-between-teacher variation to identify the effects of teachers' abilities, it is important to have sufficient within-student variation in the data. In *Table A3* in the Appendix, where we decompose the standard deviation in teacher abilities into the within-student and between-student variation, we find that the within-student variation is about the same as the between-student variation (or slightly larger) for all three ability measures.

5 Results

In section 2 we showed that the abilities of teachers are declining over time, a pattern found for several other countries. Whether this development is a matter for concern crucially depends on whether or not these general abilities actually matter for student achievement. In this section we present estimates of the causal link between teacher abilities and student outcomes. In sum, we find little evidence that teachers with high cognitive or social interactive abilities would improve the achievement for the average student. However, there are important asymmetries between different student types, and between male and female teachers.

5.1 Baseline effects of teacher abilities

We begin by analysing the average impact of teacher abilities on student achievement using the identification strategy presented in section 3.[20] In all specifications, we control for student, time-specific subject effects, as well as teacher birth cohort. Student fixed effects deal with the sorting of students to teachers. Subject-year fixed effects take care of the selection of teachers to different subjects and that the relative difficulties of the subject tests may vary from year to year. Birth cohort dummies control for changes in teacher education as well as potential changes in the ability evaluations. In addition, birth cohort is a close proxy for

[20] An implicit assumption in our identification strategy of comparing students' performance in different subjects across different teacher abilities is that there are no spill-over effects of performance between subjects; such an effect would bias our results downwards. When testing for this we find no evidence that results in one subject is influenced by the abilities of teachers in other subjects.

teacher experience. In the teacher GPA regressions we also take teacher gender and upper-secondary program fixed effects into account.

The baseline results of how teachers' abilities affect student outcome are shown in *Table 2*. The first column shows that the estimated effect of cognitive ability score on student outcomes is close to zero while the estimated effect of social ability (column 2) is positive but small and not statistically significant. The standard error on the coefficient for social ability is small, suggesting that the effect is precisely estimated. The coefficient for cognitive ability is less precisely estimated, indicating that effects may be heterogeneous. In the third column where both the cognitive and social ability are included the estimates are unchanged. In other words, there is no indication that higher cognitive or social abilities among teachers will lead to better (or worse) student performance on standardized tests.

The benefit of using cognitive and social abilities from the draft is that these measures are designed and validated to capture specific abilities. The drawback is that they are only available for male teachers. We therefore turn to teachers' standardized upper-secondary school grade point average (GPA), which captures a mix of cognitive ability and character traits like adaptability, ambition, motivation, maturity and conscientiousness. As a high upper-secondary school GPA gives access to selective post-secondary education programs, it also provides a measure of alternative career opportunities.

In column 4, we find that a teacher with a high GPA is not, on average, more effective in enhancing student performance. The estimated coefficient is close to zero and quite precisely estimated. In columns 5 and 6 we run the GPA regressions separately for male and female teachers. In column 5 we find a large positive and statistically significant effect for male teachers, indicating that a one standard deviation higher male teacher GPA results in a 0.13 standard deviation higher student achievement. Compared to the size of the estimated effects in previous work (Rockoff, 2004; Rivkin et al, 2005; Rockoff et al, 2011) this is a substantial effect. For female teachers (column 6) the estimate is small and even negative. Despite the small standard errors the estimate is not statistically significant, however.

[Table 2]

In essence, the general ability captured by teachers' upper-secondary GPA has different implications for male and female teachers. While male teachers with a higher GPA score are more effective, female teachers with higher upper-secondary school GPA are not better at raising student achievement than women with a lower GPA. One reason for this difference may be that the GPA captures different capacities for men and women. Lindahl (2007) finds evidence that girls' school grades to a larger extent capture other competences than what is measurable in objective test scores. As these differences are rather small a more plausible explanation is that there are gender differences in the selection into the teacher profession. It is possible that males who—despite having all the career opportunities a high GPA entails—chose to become teachers are particularly motivated. For some reason, a different selection process may be present among women with high GPA-scores. Yet another possibility is that the school environment itself, for some reason, hampers the performance of high-GPA female teachers.

As a general check of the robustness of these results, we in

Table **A3.** Skills within- and between-student in the identifying sample

Variable		*Mean*	*Std. Dev.*	*Min*	*Max*
Cognitive	Overall	0.571	0.738	-1.669	2.084
	Between		0.5045	-1.080	1.773
	Within		0.540	-1.264	2.407
Social	Overall	0.340	1.001	-2.450	2.323
	Between		0.651	-1.106	1.719
	Within		0.757	-1.450	2.642
GPA teacher	Overall	0.465	0.738	-2.416	2.770
	Between		0.491	-1.333	1.902
	Within		0.553	-1.572	2.400

Table A4 in the Appendix depart from our preferred specification presented above. In order to test the importance of functional forms, we add squared ability terms to the analysis (columns 1-3 and 5-7); we do not find any indication of non-linear effects of teacher ability on student achievement. There is ample evidence in the literature suggesting that cognitive and non-cognitive personality traits can reinforce each other (Borghans et al, 2008) and it is therefore possible that different teacher abilities influence each other in the actual teaching situation. For these reasons we introduce an interaction term between the cognitive and social abilities (column 4); we find a positive cross-term suggesting that teachers with a high ability to interact socially are particularly productive if also equipped with a high cognitive ability.

For all three measures we use, teacher abilities are evaluated at about age 18. This begs the question regarding the stability of ability rankings over time. Regarding cognitive ability, there is evidence (Hopkins and Bracht, 1975; Schreuger and Witt, 1989) that the rank-order correlation over time is high and plateaus long before age 18. At the same time, the mean levels of cognitive skills decline substantially with age (Schaie, 1994). The rank-stability of non-cognitive abilities is lower but still substantial, at least when these abilities are evaluated at age 18 (Roberts and DelVecchio, 2000).[21] As opposed to cognitive skills, ability traits such as emotional stability and conscientiousness are increasing rather than declining over time (Roberts et al, 2006).

In *Table A5*, we therefore test if the importance of abilities changes with age. Columns 1-3 do not give any indication that the effect of cognitive and social abilities would change with age. For male teachers on the other hand, we find some indication that the positive impact of a high GPA score becomes muted over time. The estimated effects suggest that a one standard

[21] The rank-correlation between cognitive tests taken today compared to tests taken ten years ago is about 0.78. The rank-correlation between non-cognitive abilities evaluated with an average time-interval of seven years is about 0.5 at age 18 (see Borghans et al, 2008, figures 5a and 5b).

deviation higher GPA for a 30 year old male teacher increases student performance by 0.2 standard deviations, but only by 0.145 standard deviations for teachers at age 40. There is some indication of a similar effect among female teachers but the standard errors are large and the estimates not statistically different from zero. One caveat here is that the age distribution of teachers for whom we observe GPAs is quite narrow.

5.2 The identifying assumptions

The main identifying assumptions are that there is i) no subject-specific sorting of students to teachers, conditional on average student achievement; ii) no subject and gender specific selection on unobserved abilities into the teaching profession; and iii) that the production technology is the same across subjects.

In the absence of data on past subject-specific student achievement, testing the first assumption is not straightforward. For a subset of students, however, we have data on which upper-secondary program their parents attended. We code these programs according to whether they had a mathematics/science profile or not.[22] We then create a dummy variable called *subject bias* which takes the value one (1) for mathematics if either parent attended a math/science program and zero (0) otherwise. Likewise, it takes the value one (1) for English and Swedish if either parent attended a linguistic program and zero (0) otherwise.

We then regress students' test scores on the indicator for subject bias using the baseline specification; i.e. analogous to equation (1). As can be seen in columns (1) and (3) in Appendix *Table A6*, students do tend to perform asymmetrically better in subjects for which their parents' educational choices signal that they should overachieve. However, as shown in column (2) there is no indication that this subject bias is systematically related to the cognitive

[22] Electricity (El-Tele), Two-year Technical (2-årig teknisk), Process technical (Processteknisk), Scientific (Naturvetenskaplig) and Four-year Technical (4-årig teknisk) were coded as having a math bias.

or non-cognitive abilities of their teachers. For the GPA-sample in column (4), we find a statistically significant negative relation: students with a bias in a particular subject receive on average a teacher in that class who has a lower high school GPA compared with their teachers in other subjects. The point estimate is however small and the potential bias introduced would lead us to underestimate the impact of teacher GPA on student outcomes.[23]

In order to test whether our measures of skill convey different information for teachers in different subjects we in column (1) of *Table 3* regress cognitive skills on social interactive skills, and find no evidence that the relation differs by subject taught. In columns (2) and (3) we regress our measures of teachers' cognitive and social skills on information on their body-mass-index (BMI) at the military draft. BMI is an indicator that captures other personal characteristics than both cognitive and non-cognitive skills and is related to future earnings (Lundborg et al 2010). We cannot reject the hypothesis that the relation between observed skills and BMI is equal across subjects. In order to test if the teachers' GPA conveys different information by gender we in columns (4) and (5) regress teachers' GPA on the cognitive and social skills of the teachers' full brothers. These relations do not differ by gender. Moreover, when we in column (6) and (7) interact this model with the teachers' subject, we cannot find any evidence of a gender-subject specific correlation between teachers' GPA and their brothers' skills as measured at the draft.

[Table 3]

The second major concern is whether the impact of teacher abilities differs by subject. We address this issue by dropping one subject at the time, hence identifying effects only on two subject combinations. In the Appendix we do this for the draft sample, *Table A7*, and for the

[23] The indicator for subject bias is only observed for 60 percent of the students (and student-test score observations) in our data, which is why we do not use it as a control variable in the analysis. The baseline results are essentially unchanged when controlling for subject bias (estimates available upon request).

GPA-sample *Table A8*. In the draft sample, we find no indication of such asymmetries between subjects when dropping either Swedish or English from the regressions. However, when dropping mathematics the effects of both cognitive and social interactive abilities are significantly *negatively* related to student achievement. What should be kept in mind here is that we for the combination Swedish-English identify effects using very few teachers (53). The reason for this is that students rarely have two different male teachers in this subject combination. Due to the small sample, these estimates should be interpreted with some care. Turning instead to the GPA sample, the point estimates are quite stable between the different specifications. Our conclusion from this exercise is that different impact of teacher abilities across subjects is unlikely to be a major concern.

As an additional test of differences in the production technology between subjects, we estimate a model with family-subject specific fixed effects. This estimator is based on the assumption that there is no correlation between teacher skills and unobserved student abilities, conditional of subject-specific family fixed effects. If this assumption holds, the model estimates a causal effect of teacher skills on student test scores within, rather than between, subjects. That is,

$$Test\ score_{ifst} = b_{c,s}\sum_s D_s \times Cognitive_t + b_{nc,s}\sum_s D_s \times Social_t + b_c Cognitive_t + b_{nc} Social_t + X_i{'}b_i + X_t{'}b_t + D_{fs} + e_{ifst},$$

where $Test\ score_{\text{ifst}}$ is the test score of student i in family f in subject s taught by teacher t; D_{fs} (D_s) is a family-subject (subject) specific fixed effect; X_i is a vector of student controls (gender and birth order); X_{t} is a vector of teacher controls (cohort of birth). The parameters of interest are $b_{c,s}$ and $b_{nc,s}$: If these are significant, we can reject the null that the impact of teachers skills on test scores is asymmetric between subjects.

As seen in *Table 4*, for cognitive skills one may indeed worry about asymmetric effects across subjects: relative to the impact on English, the coefficient for Swedish and, in particular, for mathematics is positive. For social interactive ability, however, we find no indication that effects would differ between subjects. This supports our interpretation of the results for the social skills but caution is warranted when interpreting the results for the cognitive skills.

[Table 4]

5.3 Heterogeneous effects of teacher abilities

We next address if different types of students respond differently to the same teacher abilities. That such heterogeneities may be of importance has been suggested by Clotfelter et al. (2006) who document that teachers with stronger math credentials generate larger achievement gains among relatively advantaged students. General student ability, gender, and foreign background are important determinants of school performance and are used by the Swedish National Board of Education to control for differences in pre-conditions faced by schools (general ability being proxied by parental educational attainment). Our results show that there indeed are important heterogeneities across student aptitude, gender, and foreign background.

We first examine if the average effects hide heterogeneities along the dimension of students' aptitude. Unfortunately, no aptitude measure prior to the schooling results in grade 9 is available. In order to obtain an aptitude measure, we turn to the grades each student receives in subjects not taught by their Swedish, English, and Mathematics teachers. Based on grades received in these *other* subjects, we construct an adjusted GPA that proxy for student aptitude. We then analyze if the effects of teacher abilities varies across students with different (adjusted) GPAs. It is important to bear in mind that the main effect of student aptitude is captured by the student fixed effects. Still, there may be spill-over effects across teachers in different subjects, but as long as any potential spill-over has the same effect for students with different aptitude this is not a problem. If, on the other hand, any spill-over effects were larger for high aptitude students our estimates would be lower bounds.

With these caveats in mind we, in column (1) of *Table 5*, interact teachers' cognitive and social ability with students' standardized adjusted GPA. According to this estimate, high-aptitude students will gain from teachers with a high cognitive ability, while the same high-aptitude students actually will suffer from being matched to a teacher with high social ability. As this specification is quite restrictive we, in columns (2) and (3), estimate separate regressions for high- and low aptitude students. Students are grouped according to the median value of the adjusted GPA and by estimating the effects of cognitive and social ability for these student groups separately we impose little structure on any heterogeneous effects. In the first row, we see that the coefficient on teacher cognitive ability is positive among high-aptitude and negative among low-aptitude students. While one of these estimates is only borderline significant, the difference between the estimates is highly statistically significant. This suggests that a one standard deviation increase in teacher cognitive ability will increase the achievement gap between high- and low aptitude students by about 0.1 standard deviations. To get a perspective on the size of this effect, it is useful to note that the average difference in test scores between these two student groups is 1.13 standard deviations.

Next we see that the estimated effect of social ability among low-aptitude students is positive and significant. The point estimate indicates that a one standard deviation increase in social ability will raise the achievement among these students by 0.043 standard deviations. Among high aptitude students, the estimated effect is negative, small and not statistically significant. The difference between these two estimates is again highly significant and suggests that a one standard deviation increase in teacher social ability will reduce the achievement gap between high and low aptitude students by about 0.05 standard deviations.

[Table 5]

Moving on to the abilities captured by teachers' upper-secondary school GPA, we do not find any substantial differences between high- and low aptitude students when estimating the effects separately for these groups. Even though the interaction term in column (4) is negative and significant, the estimates when splitting the sample are not statistically different from one another.

As the previous results show that male and female GPA scores have very different effects on student achievement, we in *Table 6* split the sample according to both students aptitude and teachers' and students' gender. We find small and insignificant effects of female teacher GPA among all groups of students, while the positive estimates for male teacher GPA are present in all groups. The largest point estimate is among low aptitude boys (0.16) and the lowest (0.08) is among low aptitude girls.

[Table 6]

In *Table A9* we then repeat this exercise using the ability measures from the military draft. It appears as if high cognitive (male) teachers and low aptitude girls are a particularly bad match. A one standard deviation increase in teacher cognitive ability would according to these estimates, reduce achievement among low aptitude girls by 0.084 standard deviations. The impact on high aptitude girls is positive (0.058) and statistically significant. The same asymmetric pattern is apparent among boys: a high cognitive teacher appears to be relatively more effective when teaching high aptitude boys, even if the difference does not reach statistical significance. These results suggest that increasing teacher cognitive ability would increase the achievement gap between high- and low performers, in particular among girls. The impact of teachers' social ability among low aptitude girls is positive (0.046) and statistically significant. While social ability has a negligible impact on high aptitude girls, the difference between the two groups of girls is statistically significant. Also among boys, teachers with high social ability appear to be relatively more effective when teaching low aptitude students. According to the estimates for male students, teachers with a high social ability have a negative impact on the test scores among high aptitude boys. As for girls—and opposite the results for cognitive ability—the estimates indicate that higher social ability among teachers would reduce the achievement gap between high and low aptitude students.

As an alternative approach to analyse asymmetries of teacher cognitive and social abilities across students, we in *Table 7* estimate if the probability that students achieve above particular thresholds in the test score distribution is related to the abilities of their teachers. The basic patterns of the estimates are those that are suggested by the above analysis, in particular for the social interactive ability. The estimates for teacher social ability show positive effects in the lower end of the distribution, while signs are negative at the top end. Correspondingly, the impact of teacher cognitive ability goes from negative to positive as we move up the achievement distribution. The dependent variable in these analysis—an indicator of whether an individual has passed a particular threshold in the test score distribution—entails considerably less variation than in the more parametric analysis in *Table 5*, consequently the estimates have much less precision and reach statistical significance only in the high and low ends of the distribution. Moreover, even if the results are qualitatively similar it is difficult to compare the point estimates of the two analyses since both the outcomes variable and the sources of heterogeneity differ.

[Table 7]

So far, we have tested for differences in the impact of teacher abilities across students with differing academic aptitude and gender. Another potentially important dimension of student heterogeneity is whether students have a foreign background or not. We define students to have a foreign background if they are either born abroad or if both their parents are born abroad. Such students are likely to have special educational needs due to language problems; an inferior knowledge of how the school system works and what are expected from students; and potentially also traumatic experiences from the home country. *Table 8* shows that there are no asymmetries between foreign and domestic students related to the effects of teachers'

GPA or cognitive ability. Students with a foreign background do, however, appear to benefit from being matched to a teacher with a high social interactive ability. The point estimate is statistically significant and relatively large (0.086). This indicates that being matched to a teacher at a one standard deviation higher position in the social ability distribution would reduce the achievement gap relative to non-foreign students by 20 percent (the gap is 0.45 standard deviations). When we break up data by foreign/non-foreign background and student aptitude we find that foreign students of both high and low aptitude benefit from having a teacher with high social ability, see *Table A10* in the Appendix. For Swedish students (and for cognitive skills) the pattern is however similar to that in *Table 5*.

[Table 8]

To sum up, the effects on student achievement by any one teacher ability appear to be highly asymmetric, either between different student groups or between male and female teachers. Teachers with high cognitive ability tend to increase the achievement gap between high- and low aptitude students while teachers with high social abilities tend to reduce it. In particular, (male) teachers with high cognitive ability appear to be detrimental to the achievement of low aptitude girls and (male) teachers with high social ability are beneficial to the achievements of students with a foreign background. From our analysis we cannot get at the mechanism for why teachers' social is particularly beneficial for students with foreign background; that is, whether this is due to factors like social identity or an ability to meet the specific needs of group. An additional finding that stands out is that male teachers with a high GPA have large beneficial impacts for most students. No such positive effects from being assigned to a female teacher with a high GPA can be found. These findings suggest that any one indicator of teacher ability is unlikely to be good all-purpose-vehicle when recruiting teachers.

6 Discussion

In section 2, we documented how entering subject teachers in the Swedish middle school are increasingly drawn from lower parts of the distribution of cognitive ability, social interactive ability, and the abilities captured by the upper-secondary school GPA. This decline in teacher abilities coincides with a marked decline in student achievement in Sweden: Among the 49 countries analysed by Hanushek et al (2012), Sweden suffered the largest decline in international comparisons of student achievement between 1995 and 2009.[24]

At first glance the decline in the social and cognitive ability of entering teachers does not appear to have had any major consequences for the average student. Our results suggest that the effects could differ across the achievement distribution, however. The gradual decline in social interactive ability by about 0.4 standard deviations has made it relatively more difficult for low achieving students to reach high educational standards. According to our estimates, such a decrease in social ability corresponds to an increase in the achievement gap between high and low aptitude students by approximately 0.02 standard deviations. Another important finding is that teacher social ability is particularly important for foreign students. A decline in the social ability among teachers by 0.4 deviations corresponds to a 0.045 standard deviation decrease in the achievement of students with a foreign background. The decline in cognitive ability among new teachers has been about 0.5 standard deviations since the peak in the early 1990's. According to our estimates, this corresponds to a decrease in the achievement gap between high- and low aptitude students by approximately 0.04 standard deviations. According to our estimates, the declines in teacher cognitive and social abilities thus have

[24] By pooling results from PISA, TIMSS, and PIRLS, Hanushek et al (2012) estimate the decline in Sweden to be approximately 0.35 standard deviations.

counteracting effects on the achievement distribution. It is indeed an open question whether or not the achievement distribution has widened or narrowed over time in Sweden.[25]

The marked decline in GPA for male and female teachers has very different implications. While the drop in GPA among male subject teachers entering the teacher profession has been detrimental for student performance—and more or less equally bad for all groups of students alike—the similar drop in the ability among female teachers does not appear to have had the same consequences. The decline in average male GPA by 0.35 standard deviations corresponds to a 0.05 standard deviation decline in average achievement.

These calculations build on the assumption that the decline in teacher ability has been uniform across different groups of students. In reality, this is unlikely to be the case. Depending on how student-teacher matching has changed over time, the consequences of the ability decline can be more or less severe for student achievement. The overall picture that emerges is complex, and suggests that it is difficult to draw a general conclusion about malign consequences of the successive decline in abilities among teachers.

7 Conclusions

The main contribution of this paper is that we find important asymmetries in how teacher abilities affect student achievement. In particular, teachers with high social abilities decrease the achievement gap between high and low achieving students. For teachers cognitive ability the pattern is the opposite: teachers with high cognitive abilities tend to increase the achievement gap between strong and weak students. This latter result should however be

[25] Evidence from TIMSS suggests that the decline has been the largest at the top of the achievement distribution, while PISA suggests a larger decline in the bottom of the distribution. Evidence from PIRLS is mixed (Fredriksson and Vlachos, 2011). Futher, Böhlmark and Holmlund (2012) find that the impact of family background on student achievement has been quite stable over time.

interpreted with caution since the identifying assumption of a symmetric impact of abilities across subjects may be violated for cognitive abilities. Our results may help explain why previous research has had difficulties identifying a relation between observable teacher characteristics and average student achievement.

An important caveat is that we only have cognitive and social ability evaluations for male teachers. Our results when using teacher upper-secondary grade point average (GPA) as a measure of teacher ability suggest that it is by no means obvious that results are uniform between male and female teachers. An increase in male teacher GPA by one standard deviation corresponds to an increase in average student achievement by 0.13 standard deviations and this effect is relatively uniform across different groups of students. For female teachers, no such positive effects are found. These findings could suggest that school grades capture different capacities for men and women or they could reflect that the selection process into the teacher profession differs substantially between men and women. This said, we find no support for either of these hypotheses. Whether the gender differences we find generalize to other settings and to better understand these differences are important avenues for future research.

In this paper, we document a marked decline in teacher abilities. Over a 15 year period, the average cognitive ability among new teachers has declined by about 0.5 standard deviations in the Swedish middle school. For social interactive ability the decline is 0.4, and for upper-secondary GPA about 0.35 standard deviations. Though we lack data for women in some ability dimensions, our results indicate that the decline is—if anything—even more dramatic among female teachers than among males. With the exception of the GPA decline among male teachers, our findings indicate that this decline has not had a marked impact on average student achievement. An important caveat to this result is that there may be important peer effects between teachers (Jackson and Bruegmann, 2009).

The picture on what abilities are productive for teachers is complex, and it is difficult to draw general conclusions on the desirability of having teachers from the upper part of the overall ability distribution. Equating teacher quality with measures of human capital like cognitive and non-cognitive abilities seems questionable. What our results do indicate, however, is that the process matching students to teachers is important. The teacher who is good for the best is not necessarily good for the rest.

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Appendix

Table A1. Ability trends among the full brothers of new subject teachers (ages 25-30)

	(1) Cognitive (men)	(2) Cognitive (women)	(3) Social (men)	(4) Social (women)
Trend (×100)	-0.960***	-1.246***	-0.111	-0.528**
	(0.229)	(0.268)	(0.227)	(0.202)
	[0.352] a)		[0.304] a)	
Observations	28	28	28	28
R-squared	0.38	0.56	0.01	0.26

Note: The dependent variables in columns (1)-(5) are standardized cognitive ability, social ability, or grade point average of the entering teachers aged 25-30 by year. The dependent variables in columns (6)-(9) are the mean of cognitive or social ability of the brothers of all entering teachers aged 25-30 by year. a) is the p-value from testing the equality of coefficients between sample trends. Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table A2. Summary statistics of teachers by subject

	(1a)	(2a)	(3a)	(4a)	(4a)	(5a)
	Draft sample					
	Swedish		English		Math	
	Non-Identifying teachers	Identifying teachers	Non-Identifying teachers	Identifying teachers	Non-Identifying teachers	Identifying teachers
Social ability	***0.376***	***0.108***	0.323	0.174	0.509	0.449
	(0.945)	***(1.022)***	(0.953)	(1.055)	(0.937)	(0.864)
Cognitive ability	0.458	0.402	0.511	0.467	0.753	0.722
	(0.758)	(0.721)	(0.860)	(0.705)	(0.765)	(0.763)
Age	39.933	39.884	39.337	40.059	38.773	38.715
	(8.197)	(8.073)	(8.476)	(8.578)	(8.183)	(8.046)
# of teachers	149	96	89	85	312	141
	(1b)	(2b)	(3b)	(4b)	(4b)	(5b)
	GPA sample					
	Swedish		English		Math	
	Non-Identifying teachers	Identifying teachers	Non-Identifying teachers	Identifying teachers	Non-Identifying teachers	Identifying teachers
GPA teacher	0.466	0.492	0.501	0.508	0.345	0.296
	(0.766)	(0.765)	(0.757)	(0.785)	(0.757)	(0.703)
Female teacher	0.721	0.795	0.743	0.804	0.592	0.554
	(0.450)	(0.404)	(0.439)	(0.397)	(0.493)	(0.498)
Age	32.741	32.990	32.924	32.971	32.743	32.832
	(4.335)	(3.956)	(4.262)	(3.950)	(3.689)	(3.886)
# of teachers	179	483	140	439	201	487

Note: Mean values of all variables and standard deviations in parentheses. Variables displayed in italics are significantly different between identifying and non-identifying students on the 5 percent level.

Table A3. Skills within- and between-student in the identifying sample

Variable		*Mean*	*Std. Dev.*	*Min*	*Max*
Cognitive	Overall	0.571	0.738	-1.669	2.084
	Between		0.5045	-1.080	1.773
	Within		0.540	-1.264	2.407
Social	Overall	0.340	1.001	-2.450	2.323
	Between		0.651	-1.106	1.719
	Within		0.757	-1.450	2.642
GPA teacher	Overall	0.465	0.738	-2.416	2.770
	Between		0.491	-1.333	1.902
	Within		0.553	-1.572	2.400

Table A4. Alternative functional forms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Standardized test scores						
Teacher sample	Draft	Draft	Draft	Draft	All GPA	Male GPA	Fem GPA
Student sample	All	All	All	All	All	All	All
Cognitive	-0.0015		-0.0079	-0.0047			
	(0.0312)		(0.0315)	(0.0234)			
Cognitive^2	0.0049		0.0087				
	(0.0194)		(0.0194)				
Social		0.0025	0.0032	-0.0263			
		(0.0155)	(0.0157)	(0.0189)			
Social^2		0.0205	0.0207				
		(0.0129)	(0.0130)				
Cognitive× Social				0.0542***			
				(0.0208)			
Teacher GPA					-0.0025	0.1461***	-0.0227
					(0.0110)	(0.0391)	(0.0159)
Teacher GPA^2					-0.0048	-0.0218	0.0051
					(0.0074)	(0.0345)	(0.0103)
Observations	31502	31502	31502	31502	71903	21096	50807
# students	26192	26192	26192	26192	46472	18236	36230
# teachers	740	740	740	740	1603	495	1108
R-squared	0.93	0.93	0.93	0.93	0.87	0.95	0.90

Note: The dependent variable is standardized student test scores in Swedish, English, and Mathematics. *Cognitive* is the teacher's standardized cognitive ability from the military draft. *Social* is the teacher's standardized social interactive ability from the military draft. *Teacher GPA* is the teacher's standardized upper-secondary GPA. Control variables include teacher birth cohort, subject×year, and student fixed effects. Columns (5)-(7) also include teacher upper-secondary school program fixed effects, and column (4) a teacher gender indicator. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered by teacher.

Table A5 Teacher age

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Standardized test scores					
Teacher sample	Draft	Draft	Draft	All GPA	Male GPA	Fem GPA
Student sample	All	All	All	All	All	All
Cognitive	0.0123		0.0160			
	(0.0947)		(0.0989)			
Cognitive×Age	-0.0003		-0.0004			
	(0.0024)		(0.0025)			
Social		0.0008	0.0013			
		(0.0878)	(0.0893)			
Social×Age		0.0001	0.0001			
		(0.0022)	(0.0023)			
Teacher GPA				0.1738**	0.3134	0.1338
				(0.0683)	(0.2530)	(0.1070)
Teacher GPA× Age				-0.0054***	-0.0054***	-0.0057
				(0.0020)	(0.0072)	(0.0031)
Observations	31502	31502	31502	71903	21096	50807
# students	26192	26192	26192	46472	18236	36230
# teachers	740	740	740	1603	495	1108
R-squared	0.93	0.93	0.93	0.87	0.95	0.90

Note: The dependent variable is standardized student test scores in Swedish, English, and Mathematics. *Cognitive* is the teacher's standardized cognitive ability from the military draft. *Social* is the teacher's standardized social interactive ability from the military draft. *Teacher GPA* is the teacher's standardized upper-secondary GPA. Control variables include teacher birth cohort, subject×year, and student fixed effects. Columns (4)-(6) also include teacher upper-secondary school program fixed effects, and column (4) a teacher gender indicator. Robust standard errors in parentheses and clustered by teacher.

Table A6. Predetermined subject bias

	(1)	(2)	(3)	(4)
	Draft sample		GPA-sample	
	Test score	Subject bias	Test score	Subject bias
Subject bias	0.085***		0.076***	
	(0.024)		(0.009)	
Social ability		-0.009		
		(0.009)		
Cognitive ability		0.008		
		(0.012)		
Teachers GPA				-0.011**
				(0.005)
Observations	18760	18760	44106	44106
# students	15587	15587	27968	27968
# teachers	709	709	1563	1563
R-squared	0.93	0.88	0.8552	0.7229

Note: The dependent variable is indicated in column header. Control variables include teacher birth cohort, subject×year, and student fixed effects. The variable Subject bias is a variable taking the value one for math (Swedish and English) if either parent has a high school degree with a math (language) focus. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%, Standard errors are clustered by teacher.

Table A7. Baseline within student estimates: Subject-by-subject combinations for draft sample

	(1)	(2)	(3)
Subject combination	English & Math	Swedish & Math	Swedish & English
Cognitive	0.0318	-0.0060	-0.1314***
	(0.0343)	(0.0338)	(0.0467)
Social	0.0118	0.0143	-0.0505**
	(0.0181)	(0.0308)	(0.0207)
Observations	23836	25130	14038
# students	21700	23244	12005
# teachers	593	663	332
R-squared	0.96	0.97	0.95

The dependent variable is standardized student test scores in Swedish, English, and Mathematics. *Cognitive* is the teacher's standardized cognitive ability from the military draft. *Social* is the teacher's standardized social interactive ability from the military draft. Control variables include teacher birth cohort, subject×year, student fixed effects. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered by teacher.

Table A8. Baseline within student estimates: Subject-by-subject combinations for GPA sample

	(1)	(2)	(3)
Subject combination	English Math	Swedish Math	Swedish English
Teacher GPA	0.0024	-0.0198*	-0.0109
	(0.0105)	(0.0108)	(0.0122)
Observations	48438	49070	46298
# students	39065	39490	34666
# teachers	1232	1326	957
R-squared	0.92	0.93	0.92

The dependent variable is specific percentiles of the standardized student test scores in Swedish, English, and Mathematics. *GPA* is the teacher's standardized average grade from high school. Control variables include teacher gender and birth cohort, subject×year, student fixed effects and upper-secondary school program fixed effects. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered by teacher.

Table A9. Heterogeneous effects by student gender and aptitude: Draft measures

	(1)	(2)	(3)	(4)
	Dependent variable: Standardized test scores			
Student sample	Girls High GPA	Girls Low GPA	Boys High GPA	Boys Low GPA
Cognitive	0.0575**	-0.0839**	0.0496	-0.0213
	(0.0283)	(0.0365)	(0.0336)	(0.0314)
	[0.000] a)		[0.051] a)	
Social	0.0043	0.0463**	-0.0373*	0.0313
	(0.0174)	(0.0216)	(0.0215)	(0.0234)
	[0.072] a)		[0.003] a)	
Observations	8942	6266	6408	9606
# students	7394	5249	5389	7967
# teachers	652	690	641	714
R-squared	0.92	0.91	0.92	0.91

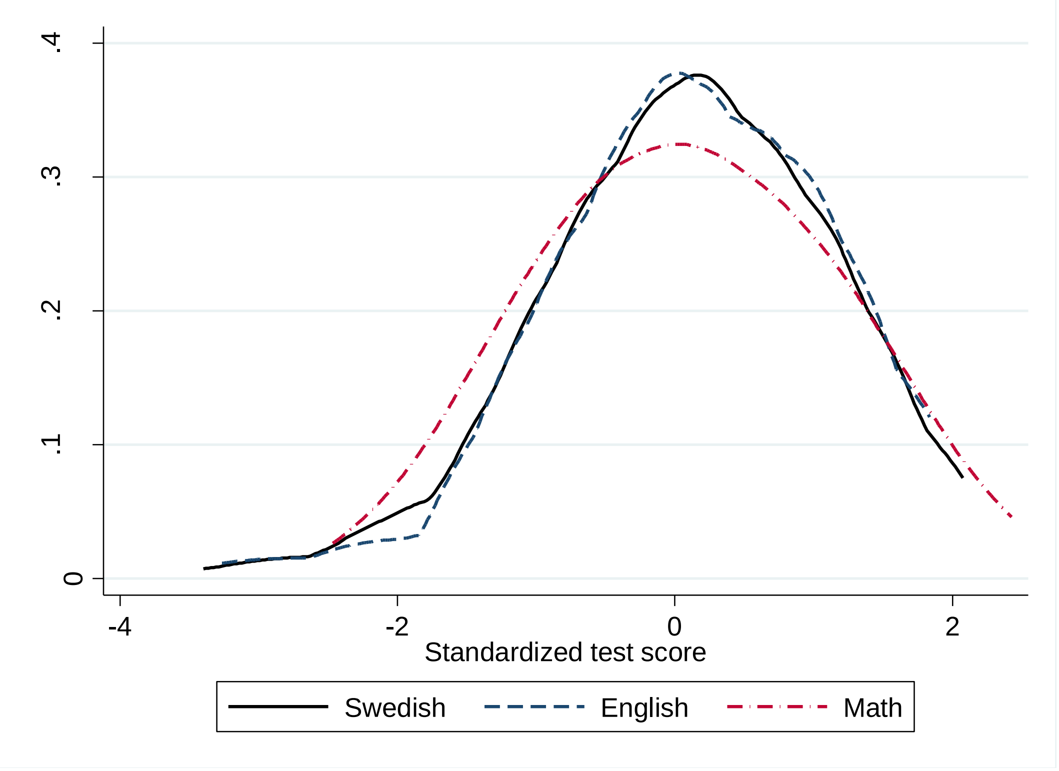
Note: The dependent variable is standardized student test scores in Swedish, English, and Mathematics. *Cognitive* is the teacher's standardized cognitive ability from the military draft. *Social* is the teacher's standardized social interactive ability from the military draft. *Teacher GPA* is the teacher's standardized upper-secondary GPA. Control variables include teacher birth cohort, subject×year, student, and teacher upper-secondary school program fixed effects. The sample is split by student gender and the median of the student GPA calculated using the subjects not taught by the Swedish, English, or mathematics teachers. a) Is the p-value from testing for equality of coefficients between the samples. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered by teacher.

Table A10. Foreign and non-foreign by student aptitude

	(1)	(2)	(3)	(4)
	Dependent variable: Standardized test scores			
Teacher sample	Draft	Draft	Draft	Draft
Student sample	Foreign	Foreign	Non foreign	Non foreign
	High GPA	Low GPA	High GPA	Low GPA
Cognitive	0.0518	-0.0781*	0.0464*	-0.0477
	(0.0395)	(0.0440)	(0.0268)	(0.0304)
	[0.019] a)		[0.001] a)	
Social	0.0527*	0.1047***	-0.0133	0.0231
	(0.0313)	(0.0295)	(0.0166)	(0.0210)
	[0.225] a)		[0.092] a)	
Observations	2556	4108	12794	11764
# Students	2143	3415	10640	9801
# Teachers	544	602	602	714
R-squared	0.92	0.91	0.91	0.91

Note: The dependent variable is standardized student test scores in Swedish, English, and Mathematics. Cognitive is the teacher's standardized cognitive ability from the military draft. Social is the teacher's standardized social interactive ability from the military draft. Control variables teacher birth cohort, subject×year, and student fixed effects. The student sample is split according to the median value of this GPA and student background, where a student is coded as Foreign if either the student or both parents are born abroad. a) Is the p-value from testing for equality of coefficients between samples. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%, Standard errors are clustered by teacher.

Figure A1. Kernel density of the distribution of standardized test scores in Swedish, English and Math



Tables

Table 1. Summary statistics

	(1a)	(2a)	(3a)	(4a)	(4a)	(5a)
	Student variables					
Sample	GPA			Draft		
	Full sample	Non-Identifying students	Identifying students	Full sample	Non-identifying students	Identifying students
Test score	0.039	***-0.009***	***0.126***	0.026	***0.014***	***0.117***
	(0.970)	***(1.022)***	***(0.861)***	(1.006)	***(1.025)***	***(0.856)***
High education	0.118	***0.113***	***0.125***	0.122	0.121	0.126
	(0.322)	***(0.317)***	***(0.331)***	(0.327)	(0.327)	(0.332)
Foreign background	0.207	***0.225***	***0.175***	0.214	***0.216***	***0.193***
	(0.405)	***(0.417)***	***(0.380)***	(0.410)	***(0.412)***	***(0.395)***
Female student	0.491	0.490	0.494	0.486	0.486	0.487
	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)
# of students	46472	29828	16644	26192	23038	3154
	(1b)	(2b)	(3b)	(4b)	(4b)	(5b)
	Teacher variables					
Sample	GPA			Draft		
	Full sample	Non-Identifying teachers	Identifying teachers	Full sample	Non-identifying teachers	Identifying teachers
GPA teacher	0.433	0.453	0.426			
	(0.755)	(0.764)	(0.752)			

Social ability				0.376	0.415	0.308
				(0.947)	(0.937)	(0.961)
Cognitive ability				0.632	0.657	0.588
				(0.775)	(0.787)	(0.755)
Age	32.807	32.666	32.858	38.892	38.823	39.009
	(3.927)	(4.020)	(3.894)	(8.142)	(8.229)	(8.003)
Female teacher	0.691	0.682	0.694			
	(0.462)	(0.466)	(0.461)			
# of teachers	1603	422	1181	740	468	272

Note: Mean values of all variables and standard deviations in parentheses. Variables displayed in italics are significantly different between identifying and non-identifying students on the 5 percent level.

Table 2. Baseline within student estimates

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Standardized test scores					
Teacher sample	Draft	Draft	Draft	All GPA	Male GPA	Fem GPA
Cognitive	0.0040		0.0038			
	(0.0242)		(0.0241)			
Social		0.0085	0.0085			
		(0.0152)	(0.0151)			
Teacher GPA				-0.0073	0.1309***	-0.0169
				(0.0077)	(0.0295)	(0.0116)
					[0.0000][a)]	
Observations	31502	31502	31502	71903	21096	50807
# students	26192	26192	26192	46472	18236	36230
# teachers	740	740	740	1603	495	1108
R-squared	0.93	0.93	0.93	0.87	0.95	0.90

Note: The dependent variable is standardized student test scores in Swedish, English, and Mathematics. *Cognitive* is the teacher's standardized cognitive ability from the military draft. *Social* is the teacher's standardized social interactive ability from the military draft. *Teacher GPA* is the teacher's standardized upper-secondary GPA. Control variables include teacher birth cohort, subject×year, and student fixed effects. Columns (4)-(6) also include teacher upper-secondary school program fixed effects, and column (4) a teacher gender indicator. [a)] Is the p-value from testing for equality of coefficients between the samples. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%, Standard errors are clustered by teacher.

Table 3. Relation between teacher abilities by the subject taught and gender

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Teacher characteristic						
	Cognitive	Cognitive	Social	GPA	GPA	GPA	GPA
Main dependent variable:							
Social	0.201***						
	(.0502)						
BMI		-0.026	0.074**				
		(0.024)	(0.031)				
Brother's cognitive				2.187**		1.919	
				(1.102)		(1.532)	
Brother's social					1.045	.	1.824
					(1.081)	.	(1.398)
Interaction term:							
Main×Swedish	-0.050	0.028	-0.013			-0.0482	-1.669
	(0.055)	(0.024)	(0.029)			(1.621)	(1.512)
Main×Math	-0.043	0.031	0.002			1.647	-0.850
	(0.060)	(0.026)	(0.034)			(2.207)	(2.034)
Main×Female				1.117	-1.74		
				(2.053)	(1.949)		
Main×Swedish×Female						0.290	-4.928
						(3.373)	(3.155)
Main×English×Female						2.912	-1.208
						(3.236)	(3.259)
Main×Math×Female						1.303	-1.871
						(2.626)	(2.476)
#Teachers	843	858	844	843	813	843	813

Note: The dependent variable is the teacher skill indicated in the column. The dependent variables is the teacher characteristic indicated in the rows (Social interactive ability, BMI, Brother's cognitive ability, Brother's social ability respectively), and an interaction term where this characteristic is interacted with a subject, gender or subject-by-gender indicator. In addition, columns (1)-(3) include subject fixed effects; (4)-(5) include a gender fixed effect; (6)-(7) include subject-by-gender fixed effects. All teachers are given equal weight. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%, Standard errors are clustered by teacher

Table 4. Cognitive and social ability by subject

	Test score
Cognitive	-0.5849***
	(0.1583)
Cognitive×Swedish	0.3526*
	(0.1822)
Cognitive×Math	0.6105***
	(0.1645)
Social	-0.0863
	(0.0572)
Social×Swedish	0.0201
	(0.0881)
Social×Math	0.0564
	(0.0636)
# Observations	31167
# Students	26192
# Teachers	740
# Family-by-subject fixed effects	29974
R-squared	0.98

Note: The dependent variable is standardized student test scores in Swedish, English, and Mathematics. *Cognitive* is the teacher's standardized cognitive ability from the military draft. *Social* is the teacher's standardized social interactive ability from the military draft. Control variables include student control variables (gender and birth order), teacher control variables (cohort of birth), and family-by-subject fixed effects. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%, Standard errors are clustered by teacher

Table 5. Heterogeneous effects for student aptitude

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Standardized test scores					
Teacher sample	Draft	Draft	Draft	All GPA	All GPA	All GPA
Student sample	All	High GPA	Low GPA	All	High GPA	Low GPA
Cognitive	-0.0057	0.0584**	-0.0479*			
	(0.0246)	(0.0261)	(0.0290)			
Cognitive× student GPA	0.0731***	[0.000] a)				
	(0.0213)					
Social	0.0208	-0.0071	0.0428**			
	(0.0152)	(0.0158)	(0.0199)			
Social× student GPA	-0.0372***	[0.010] a)				
	(0.0131)					
Teacher GPA				-0.0017	-0.0112	-0.0001
				(0.0080)	(0.0092)	(0.0097)
Teacher GPA× student GPA				-0.0213**	[0.285] a)	
				(0.0085)		
Observations	31222	15350	15872	71568	35956	35612
# students	25999	12783	13216	46297	22791	23506
# teachers	733	680	728	1596	1533	1585
R-squared	0.94	0.91	0.91	0.87	0.81	0.83

Note: The dependent variable is standardized student test scores in Swedish, English, and Mathematics. *Cognitive* is the teacher's standardized cognitive ability from the military draft. *Social* is the teacher's standardized social interactive ability from the military draft. *Teacher GPA* is the teacher's standardized upper-secondary GPA. Control variables include teacher birth cohort, subject×year, and student fixed effects. Columns (4)-(6) also include teacher upper-secondary school program fixed effects, and column (4) a teacher gender indicator. In columns (1) and (4), teacher abilities are interacted with student GPA calculated using the subjects not taught by the Swedish, English, or mathematics teachers. In columns (2)-(3) and (5)-(6), the student sample is split according to the median value of this GPA. a) Is the p-value from testing for equality of coefficients between samples. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%, Standard errors are clustered by teacher.

Table 6. Heterogeneous effects by teacher gender and by student gender and aptitude: Teacher GPA

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Standardized test scores							
Teacher sample	Female teacher GPA				Male teacher GPA			
Student sample	Girls: High GPA	Girls: Low GPA	Boys: High GPA	Boys: Low GPA	Girls: High GPA	Girls: Low GPA	Boys: High GPA	Boys: Low GPA
Teacher GPA	-0.0220	0.0099	-0.0271	-0.0219	0.0988**	0.0755	0.1387***	0.1603***
	(0.0161)	(0.0175)	(0.0171)	(0.0154)	(0.0423)	(0.0500)	(0.0476)	(0.0437)
	[0.114] [a)]		[0.780] [a)]		[0.670] [a)]		[0.689] [a)]	
Observations	14591	10312	10847	14931	6187	4063	4331	6306
# students	10336	7451	7566	10798	5339	3581	3739	5460
# teachers	1040	1042	1035	1086	446	460	436	483
R-squared	0.86	0.88	0.86	0.88	0.94	0.94	0.94	0.93

Note: The dependent variable is standardized student test scores in Swedish, English, and Mathematics. *Teacher GPA* is the teacher's standardized upper-secondary GPA. Control variables include teacher birth cohort, subject×year, student, and teacher upper-secondary school program fixed effects. The sample is split by teacher and student gender and the median of the student GPA calculated using the subjects not taught by the Swedish, English, or mathematics teachers. [a)] Is the p-value from testing for equality of coefficients between the samples. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered by teacher.

Table 7. Linear probability of passing specific thresholds in the test score distribution

	Cognitive	Social
>-1.7	-0.0026	0.0031†
	(0.0032)	(0.0022)
>-1.5	-0.0043	0.0079**
	(0.0062)	(0.0035)
>-1.2	-0.0002	0.0092**
	(0.0078)	(0.0046)
>-1.0	0.0006	0.0052
	(0.0089)	(0.0051)
>-0.7	-0.0065	0.0067
	(0.0091)	(0.0059)
>-0.5	-0.0134	0.0011
	(0.0110)	(0.0068)
>-0.3	-0.0102	0.0036
	(0.0105)	(0.0065)
>0.0	0.0034	-0.0016
	(0.0108)	(0.0069)
>0.3	0.0083	-0.0035
	(0.0105)	(0.0070)
>0.5	0.0122	0.0001
	(0.0108)	(0.0072)
>0.7	0.0086	0.0082
	(0.0094)	(0.0061)
>1.0	0.0014	-0.0049
	(0.0078)	(0.0057)
>1.2	0.0104	0.0049
	(0.0067)	(0.0052)
>1.5	0.0054	-0.0029
	(0.0058)	(0.0045)
>1.7	0.0079†	-0.0059*
	(0.0052)	(0.0034)

The dependent variable is specific percentiles of the standardized student test scores in Swedish, English, and Mathematics. *Cognitive* is the teacher's standardized cognitive ability from the military draft. *Social* is the teacher's standardized social interactive ability from the military draft. Control variables include teacher birth cohort, subject×year, and student fixed effects. Robust standard errors in parentheses, † significant at 15%; * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered by teacher.

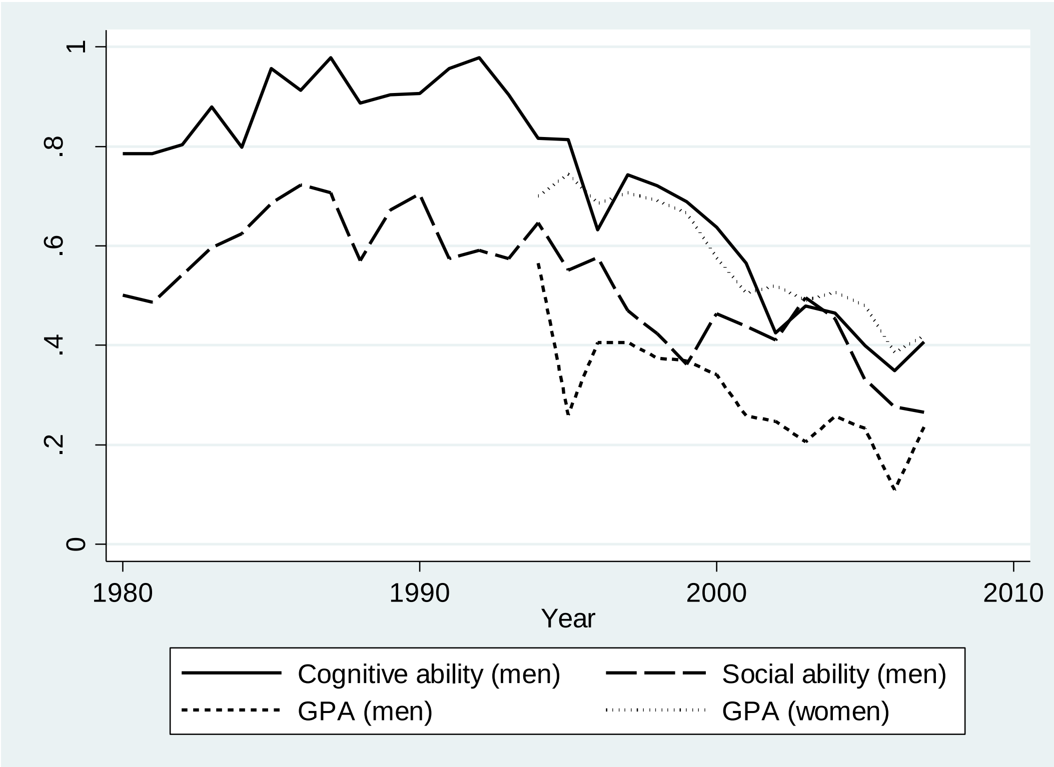
Table 8. Heterogeneous effects for foreign background

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Standardized test scores							
Teacher sample	Draft	Draft	All GPA	All GPA	Male GPA	Male GPA	Fem GPA	Fem GPA
Student sample	Foreign	Not foreign	Foreign	Not foreign	Foreign	Not foreign	Foreign	Not foreign
Cognitive	-0.0309	0.0010						
	(0.0349)	(0.0250)						
	[0.381] a)							
Social	0.0861***	-0.0053						
	(0.0219)	(0.0152)						
	[0.000] a)							
Teacher GPA			-0.0024	-0.0051	0.0680	0.1156***	0.0076	-0.0222*
			(0.0231)	(0.0106)	(0.0510)	(0.0310)	(0.0191)	(0.0113)
			[0.980] a)		[0.941] a)		[0.148] a)	
Observations	6722	24780	13935	57968	4173	16923	9762	41045
# students	5593	20599	9611	36861	3722	14514	7308	28922
# teachers	673	728	1479	1583	454	487	1025	1096
R-squared	0.93	0.93	0.88	0.86	0.96	0.95	0.91	0.89

Note: The dependent variable is standardized student test scores in Swedish, English, and Mathematics. *Cognitive* is the teacher's standardized cognitive ability from the military draft. *Social* is the teacher's standardized social interactive ability from the military draft. *Teacher GPA* is the teacher's standardized upper-secondary GPA. Control variables teacher birth cohort, subject×year, and student fixed effects. Columns (3)-(8) also include teacher upper-secondary school program fixed effects and (3)-(4) a teacher gender indicator. The student sample is split according to student background; a student is coded as *Foreign* if either the student or both parents are born abroad. a) Is the p-value from testing for equality of coefficients between samples. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1% level. Standard errors are clustered by teacher.

Figures

Figure 1. Abilities of new subject teachers (ages 25-30), 1980-2006



Note: The graph plots the average cognitive and social interactive abilities, as well as the average grade point average (GPA) of all new middle school subject teachers ages 25-30 in the Swedish teacher register.