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Job mobility among high-skilled and low-skilled teachers

Krzysztof Karbownik

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Job mobility among high-skilled and low-skilled teachers[1]

by

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Abstract

This paper examines the job mobility of teachers with different skills using matched employer-employee data from Swedish secondary schools. In addition to standard quality measures, I have access to population-wide data on cognitive and non-cognitive assessments of males born in 1951 or later. The results show that high-quality teachers are less mobile than others, and that there is no significant correlation between turnover and share of minority students. Interestingly, teachers with better skills are less likely to leave the profession, which suggests that the documented drop in the quality of inflowing teachers may partly be offset by a higher tendency for high quality teachers to stay in the profession.

Keywords: Teacher turnover, teacher quality, student composition
JEL-codes: I21, J44

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1 Introduction

Teachers are important for student achievement (Rockoff, 2004; Rivkin et al., 2005; Aaronson et al., 2007). Even though it has proved hard to pin-point exactly what makes a good teacher, a number of studies suggest that teacher effects can be related to observed measures of teacher skills. Experienced teachers have been shown to provide more skills to students than teachers that are new to the profession (Rockoff, 2004; Harris and Sass, 2011; Clotfelter et al., 2007). Few studies have found any effect of teacher education on student outcomes, but there is some evidence that more detailed information on teacher quality may be important in the production of skills. Clotfelter et al. (2007) find that teacher test scores and regular licensure have positive effects on student achievement. Rockoff and Speroni (2011) document that subjective evaluations of teacher effectiveness have a predictive power for the achievement gains of their students. On the other hand, Grönqvist and Vlachos (2008) find no overall relationship between teachers' cognitive and non-cognitive assessments and student outcomes.[3]

The quality of teachers may be of particular importance for disadvantaged students. For example, Grönqvist and Vlachos (2008) find that the effect of a teacher with high non-cognitive skills is stronger among low-performing students. At the same time, they also find that high cognitive skills' teachers might actually harm low-aptitude students. In the US Aaronson et al. (2007) find that teacher quality, measured by value added, is particularly important for lower-ability students and that a one standard deviation in teacher quality is worth as much as 24 % of average test score gain between eight and ninth grade for students from the bottom tertile of the quality distribution. At the same time, this effect for the top tertile is only 6 %. The heterogeneity in teacher effects found in the econometric analyses has also been confirmed using a random assignment of teachers to classrooms. Nye et al. (2004), using data from Tennessee STAR experiment, show that the variance of teacher effects is much larger in low than in high socioeconomic status schools. This means that in low SES schools, it matters more which teacher a child receives than it does in high SES schools. Furthermore, it suggests that interventions to replace less effective teachers with more effective teachers may be more promising for disadvantaged than for privileged children.

[3] Their empirical strategy relates within-school variation in teacher quality to within-student variation in performance between subjects, and may not be appropriate for identifying main effects of teacher quality.

School principals can try to enhance the quality of the teacher stock, either by hiring good teachers or by firing bad ones (Böhlmark et al., 2012). However, the success of such employment policies depends, in part, on the skills of available teachers to hire. Many studies have documented falling quality of new entrants into the profession over the past decades, leading to deterioration of the skills in the pool of potential teachers to hire.[4] Thus, reducing turnover among high-quality teachers must probably be crucial to any principal wishing to sustain the competence level in their school.

A growing number of studies document turnover among teachers of different quality. One strand of the literature makes use of input-based measures of teacher quality, such as certification, education and experience (Boyd et al., 2005; Feng, 2010; Barbieri et al., 2011; Clotfelter et al., 2011). However, most of these studies use quite crude quality measures, which have shown to be only weakly related to student performance. Another strand of the literature exploits output measures of teacher quality, such as the estimated value-added of different teachers. This approach is not limited to observed determinants of student performance, but the validity and stability of teacher fixed effects models have been questioned in the literature (Rothstein, 2010).

In addition to the standard input-based teacher quality measures used in the literature (education and experience), this study makes use of a population-wide data on both cognitive and non-cognitive skills among male teachers (born 1951 or later) to study teacher turnover in Swedish secondary schools. In particular, I study differences in teacher mobility, to other schools or out of the profession, among high-quality and low-quality teachers. Further, I relate any differences in teacher turnover to a number of job attributes, such as student quality, teacher wages and type of contract.

This paper should also be of interest due to the uniqueness of the Swedish institutional setup. Unlike most countries (Falch and Strøm, 2005; Jackson, 2009; Falch, 2010), the Swedish labor market for teachers does not differ much from other white-collar job markets and is an excellent example of monopsonistic competition with individual wage bargaining and a growing private sector (Manning, 2011; Karbownik,

[4] Grönqvist and Vlachos (2008) document a close to 20 percentile ranks decline in the average cognitive ability of Swedish teachers since the early 1990s and also a substantial decrease in social abilities and GPAs. Fredriksson and Öckert (2007) present evidence on a deterioration of returns to teacher education and experience among Swedish teachers. Similarly, Nickell and Quintini (2002) report severe declines in investment in teachers in Britain, while Leigh and Ryan (2008) find about 10 percentile rank declines in Australian teacher quality. Both Bacolod (2007) and Corcoran et al. (2004) document that contemporary teachers in the US are less qualified than their counterparts in the 1960s and 1970s.

2014). Similar to other countries, Sweden also struggles with attracting high skilled individuals into the teaching profession and experiences teacher shortages, yet has introduced utterly different institutions.[5]

I show that university educated and experienced teachers are less likely to both leave their current school and the profession. Furthermore, using the unique enlistment records I document that teachers with high non-cognitive skills are less likely to change employers. At the same time, I do not find robust correlations for cognitive skills when I control for standard teacher quality measures like education or experience. Moreover, I do not find any support for the common view that schools serving minority students experience higher turnover rates of high-quality pedagogues. Finally, I present robust negative correlation between teacher turnover and monetary compensations.

The paper is organized as follows: section two offers a short literature review, section three briefly presents the institutional background, data sources, and the econometric model, section four presents descriptive evidence, section five contains the main results, section six includes heterogeneity analyses, and finally section seven concludes.

2 Literature review

It is important from the education policy stand point to understand if disadvantaged schools experience outflow of high quality teachers or attract particularly bad teachers, and thus there is a growing number of studies that document turnover among teachers of different quality. Using the data from New York State, Lankford et al. (2002) show that urban (low-income, low-achieving and non-white) schools deter high quality teachers and that salary variation rarely compensates for the difficulties of teaching in these disadvantaged schools. Their measures of teacher quality are based on experience, formal education and its quality as well as certification. Furthermore, using the same dataset and quality measures Boyd et al. (2005) show that there is a significant heterogeneity in teacher responses when exposed to low-quality pupils. For example, when considering probability of separation, the top 75 percent of teachers, as measured by general knowledge certification exam, reacts much more strongly to low-aptitude students than does the bottom 25 percent. The differences in teacher turnover by

[5] Björklund et al. (2006) or National Agency for Education (2003) provide details about teacher shortages.

experience are also found in Feng (2010), who uses Florida school teachers and explores an assignment to tough classrooms. She documents that it is rather inexperienced teachers that are most likely to exit the profession when facing low-achieving and misbehaving students. Clotfelter et al. (2011) using data from yet another State in the US, North Carolina, show that teachers with stronger qualifications are both more responsive to racial and socioeconomic mix of school's students and less responsive to salary changes. The authors use four measures of teacher qualifications: teachers' average licensure test scores, alma mater competitiveness, experience and certification. In the European context, Barbieri et al. (2011) document that experienced teachers are driven away from the most difficult schools and that the major discouraging factors include high shares of disabled and foreign students, as well as students who had to repeat a grade.

Research also suggests that teachers react to changes in their working environment. Studies show that teachers are responsive to even small variation in wages (Baugh and Stone, 1982; Murnane and Olsen, 1990; Figlio, 1997; Figlio, 2002; Feng, 2009; Falch, 2011; Karbownik, 2014). Another factor affecting teachers' turnover and compensations is the competition between publicly and privately run schools (Jackson, 2012; Hensvik, 2012). It is also important to understand the differences between the wages offered to teachers in education and in other sectors of the economy (Dolton and van der Klaauw, 1995, 1999; Brewer, 1996; Fredriksson and Öckert, 2007; Dolton and Marcenaro-Gutierrez, 2011). Non-pecuniary characteristics play an important role alike and sometimes they even dominate monetary compensations (Hanushek et al., 2004). As the literature suggests, teachers are generally discouraged by high fractions of poor, minority and low-achieving students (Falch and Strøm, 2005; Scafidi et al., 2007; Barbieri et al., 2011; Bonhomme et al., 2011).[6] Finally, there is evidence that the quality of match between a school and a teacher is an important issue (Jackson, 2013).

[6] More recent literature relying on quasi-experimental methods (Jackson, 2009) and based on administrative data (Karbownik, 2014) finds rather heterogeneous impact of minorities on teacher turnover.

3 Institutional setting, data and empirical set-up

3.1 Institutions

The Swedish schooling system starts with voluntary pre-school and continues with nine years of compulsory education. Lower secondary school covers the grades 7-9. The 9th grade grades determine student's chances to advance to upper secondary school. Swedish municipalities are obliged by law to provide upper secondary schooling to all students who successfully completed compulsory education. Upper secondary school consists of different programs, lasts three years and provides eligibility for post-secondary education.

Private schooling is growing in Sweden and is encouraged by the government. In 1992, Sweden introduced a school voucher reform that allowed for both non-profit and for-profit independent schools. The municipality is obliged to pay the independent schools for each student they can attract, with an amount corresponding roughly to the average per student cost in the public schools.[7] Since the reform the fraction of private schools has risen, in particular at the upper secondary level. In the school year 2005/2006 there were 220 private upper secondary schools, which constituted 33.1 % of all upper secondary schools in Sweden, a rise from 8.1 % in 1996/1997. At the same time, the number of private lower secondary schools constituted only 15.8 % of all schools at this level starting from 3.2 % in 1996/1997.[8]

Teaching profession in Sweden is regulated and different qualifications are required depending on the subject taught and on the type of school. Teaching at the secondary school level requires completing special coursework beyond what is required from a compulsory school teacher. Individuals from other professions who want to become teachers need to supplement their professional degrees with a minimum of 1.5 years of preparation in pedagogy, didactics and teaching practice.

Municipalities are the primary employers of teachers in Sweden, and thus, handle the responsibility of recruiting them.[9] In practice, however, the decisions regarding recruit-

[7] An independent school receives around 85-95 % of the average per student cost in public schools and this varies from year to year. Some municipalities also have a socioeconomic gradient for the school voucher. The private schooling was effectively introduced at lower secondary level in 1992, and at upper secondary level in 1994 (Böhlmark and Lindahl, 2007, 2008).

[8] This information is based on registry data.

[9] For more information on the reform that shifted responsibility for schooling from the central government to municipalities see: Fredriksson and Öckert (2008). There is still a small fraction of schools run by county or state, however, those employ around 1 % of all the teachers between 1996/1997 and 2005/2006. Those schools are excluded from the analysis since they have different sources of funding and their role is diminishing.

ment, selection and employment of a teacher are made at the school level by a principal. Finally, teacher wages are determined at local level through individual bargaining between teacher and principal given the collective bargaining outcome set at the national level.[10]

3.2 Data

This paper utilizes Swedish population-wide registries. The main data source is the teacher registry that covers all teaches employed in Swedish schools in years 1996/1997 to 2006/2007. It contains information on teachers' education, specialization, experience, certification, place of work, type of contract (permanent vs. temporary) and workload. To these data I have matched background information on age, gender, immigration histories, employment and income for all teachers in the registers. The pupil registries for lower and upper secondary schools are used to obtain information on students in a given school. These allow linking children and their parents to schools, as well as obtaining the average percentile ranked GPA of the students. Administrative records on earnings provide information on teachers' monetary compensations. The details of the sample construction are discussed in the appendix.

Since, the core focus of this paper is on teacher quality, for the subsample of male teachers born 1951 or later, I use military enlistment data to obtain information on cognitive and non-cognitive test scores. Until the 1st of July 2010 the military service in Sweden was mandatory for all males aged 18-47.[11] The enlistment procedure lasts two days and comprises of medical and physical assessments, cognitive ability tests and 20 minutes semi-structured interview with a trained, and often very experienced, psychologist (Mood et al., 2012). It was not possible to avoid military service by obtaining a low score on cognitive or non-cognitive ability assessments but about 5-10 percent of enlisted men did not attend the enlistment because of the mental or physical handicaps. The data is also restricted to the natives, since only Swedish citizens were allowed and obliged to attend the enlistment.

[10] Individualized pay was introduced in 1996 and is discussed in detail by Hensvik (2012) and in survey by Lindholm (2006).

[11] At the end of 2000s not the whole population was drafted and thus the data are reliable only until 2006. The enlistment usually takes place right after upper secondary school graduation i.e., when man turns 18 or 19 years old. Among the teachers for whom I have data 96.3 % did the enlistment when they were 18 or 19, 2.3 % when they were 20, 0.3 % when they were below 18 and the remaining 1.1 % when they were older than 20 years old.

The cognitive assessment of Swedish conscripts has been conducted since the mid-1940s. The tests have changed somewhat over the years, but they have always been intended to measure the same four underlying cognitive traits: logic-inductive ability, verbal comprehension, spatial ability and technical comprehension.[12] Each of these tests was graded on a scale from 1 to 9, where 1 is the lowest possible and 9 is the highest possible score. These scores were then transformed to a discrete variable of general cognitive ability ranging from 1 to 9. In the analyses, I use the final score which is comparable across all years.

Similarly to cognitive assessment, the personality tests were introduced at the military enlistment in the early 1940s. All the men in the data had their psychological profiles evaluated according to a procedure that was adopted in 1969 and kept unchanged up to 1995 when it was subject to minor revisions. The personality assessment which is based mostly on behavioral questions can be categorized into four parts: social maturity (extroversion, having friends, taking responsibility, independence), psychological energy (perseverance, ability to fulfill plans, ability to remain focused), intensity (the capacity to activate oneself without external pressure, the intensity and frequency of free-time activities) and emotional stability (ability to control and channel nervousness, tolerance of stress, and disposition of anxiety). The general objective of the interview was to assess the conscript's ability to cope with the psychological requirements of the military service, and in the extreme case, war. As the final outcome of the interview the psychologists assign each man military aptitude score from 1 to 9, which is comparable over years.

I am able to recover information on cognitive and non-cognitive test scores for 89 % of Swedish male teachers born in 1951 or later.[13] Since most of the missing individuals were exempted from the draft due to mental and physical disabilities, there are differences in observables between them and those for whom the scores are available. More details regarding the construction of final scores used in the analyses are provided in the appendix. For details regarding the testing procedure itself and various

[12] Carlstedt (2000) describes the history of psychometric testing in the Swedish military. Unlike AFQT, the Swedish cognitive assessment is a good measure of a general intelligence.

[13] The first draft year I use is 1970 and the last one is 1999. Most of the data for individuals tested in 1978 are lost, and thus only 15 412 observations are recorded for this year. This loss is not systematically related to individual characteristics other than year of birth.

applications of Swedish military enlistment registries see: Lindqvist and Vestman (2011).

3.3 Econometric modeling

The main analysis is done using a series of binary choice models that attempt to capture the manifestation of teachers' job preferences conditional on teacher quality. Since this paper is only descriptive I am not able to identify teacher's preferences in an econometric sense. Nonetheless, it should be intuitive that leaving employment j in favor of an alternative opportunity k is related to individual preferences with respect to employers j and k. Thus, I specify the following linear model. The dependent variable is equal to unity if a teacher leaves their current employer from year to year, and such a decision is regressed on teachers' working environment and their own characteristics. In particular, these binary models show whether teachers who remain in their appointments have, on average, different quality than those who leave their jobs.

From the policy point-of-view, one should also investigate what are the factors that drive high quality teachers to seek a better employment match as such sorting of teachers may indicate permanent quality drop of particular institutions, and thus, have adverse influence on student achievement.[14] Therefore, the heterogeneity analyses based on the differences in school characteristics shed light on what job characteristics are important for low and high quality teachers. Using the main specification, I also run separate regressions depending on teacher's destination. In particular, I specify two distinct variables of transition. These are: switching schools within a teaching profession and leaving teaching in favor of a different occupation.[15] This analysis could be of interest for policy makers, as losing highly educated pedagogues in favor of other sectors of the economy may lead to worsening productivity of the whole educational system in the future.

[14] High quality teachers are these with university education (Ehrenberg and Brewer, 1994; Harris and Saas, 2011), longer experience (Rockoff, 2004), above median cognitive and non-cognitive test scores (Hanushek, 1971; Harbison and Hanushek, 1992; Grönqvist and Vlachos, 2008). A university graduate is defined as an individual graduating three, four or five year long university (hogskoleutbildning) education or an individual with a research degree. Note that other forms of post-secondary (eftergymnasial) education are not treated as university graduates.

[15] Switching to primary education or adult education is treated as school-to-school mobility. Switching to kindergarten, pre-K or university education is treated as quit. The results are robust to various definitions of school-to-school mobility and quits and are available upon request.

In order to maintain simplicity of the interpretation of the results, the estimation strategy is based on the least squares using linear probability model.[16] The following econometric model is estimated:

$$y_{ijt} = a_0 + a_1 Q_{ijt} + a_2 W_{ijt} + a_3 X_{jt} + a_4 P_{ijt} + dt \times c + e_{ijt} \qquad (1)$$

where y_{ijt} is equal to unity if teacher i leaves the current employer j at a period following t, W_{ijt} is teacher i earnings at school j and time t, X_{jt} is a vector of observable school characteristics at institution j at time t (polynomial of school size, share of girls, student-teacher ratio in full time equivalence as a proxy for school resources, share of non-Nordic students, student's precentiled GPA and mean parental income), P_{ijt} is a vector of personal characteristics of teacher i at school j and time t (gender, non-Nordic teacher indicator, marital status indicator, three specialization indicators, workload, type of school, school ownership indicator and type of employment), and ε_{ijt} is an error term that represents unobserved characteristics, which is clustered at school level. I use four types of quality indicators, Q_{ijt}. In the full sample of teachers, the quality of teacher i at school j and time t is measured using experience and education. In the sample of younger males, which is of interest due to the unique data, I use cognitive and non-cognitive military assessment of a teacher as quality measures.[17] Vector of δs captures county-by-year fixed effects.

4 Descriptive evidence

This paper focuses on four measures of teacher quality: university education, teaching experience, cognitive and non-cognitive test scores. In order to better understand how these measures relate to particular school characteristics, Figure 1 and Figure 2 plot their means against the deciles of student's GPA and share of minorities.[18] In particular, the figures illustrate the distribution of teacher quality across schools with different pool of students, which should help understanding what type of teachers in terms of quality cluster in a given type of schools.

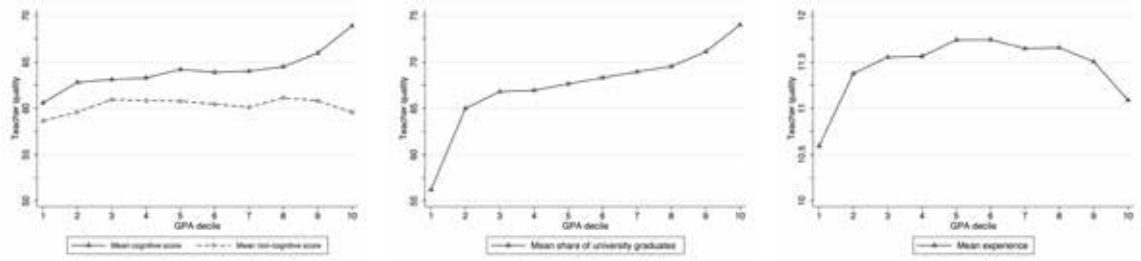
[16] This method yields very similar estimates to the non–linear models. The regressions using logit and multinomial logit models with marginal effects evaluated at mean are available upon request. Majority of correlations between explanatory variables are below 0.1 and the correlogram is available upon request.
[17] The correlation coefficient between cognitive and non-cognitive assessment in the studied sample is 0.15, which is lower than the one reported by Grönqvist and Vlachos (2008) for the whole population (0.36).
[18] Lower secondary school GPA is the percentiled GPA in 9th grade. See the appendix for details.

Teacher education correlates positively with student achievement measured by GPA, and the worst performing students are taught by a lower number of university educated teachers. At the same time, both low and high achievers are taught by rather less experienced teachers. Similar u-shaped pattern can be found in the relationship between the proportion of immigrant students and teacher experience. Finally, the slope of the relationship between the level of immigrants in school and share of teachers with university education is smaller than the one for student quality measured with GPA.

As far as intellectual assessment is concerned the patterns are mostly stable with a significant gap between cognitive and non-cognitive scores. First, teachers are more positively selected on cognitive than on non-cognitive scores. Second, teachers with higher cognitive abilities are matched to high-performing students. Third, teachers with higher cognitive skills are matched to schools with more minorities, while the opposite is true for teachers with high non-cognitive skills.

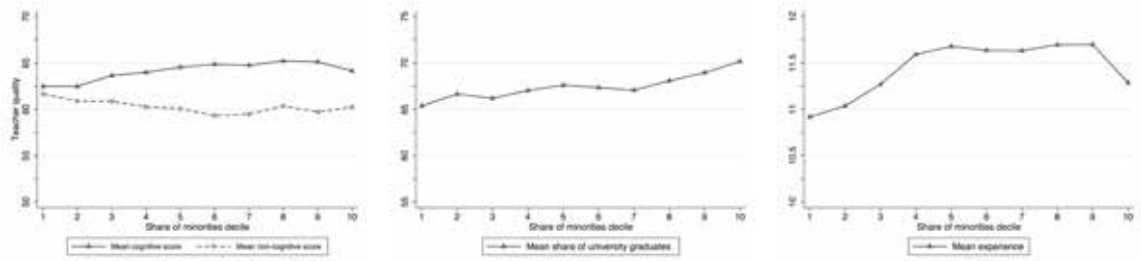
Figure 3 shows the evolvement of teacher mobility with different destinations for teachers with and without university degree. Figure 4 depicts the three mobility measures split by teacher experience, cognitive skills, and non-cognitive skills, respectively. Teacher turnover differs systematically by teachers' educational attainment. This difference is almost entirely driven by a higher probability for teachers without a university degree to leave the profession, while there is more or less no difference in the school-to-school mobility. Teacher turnover decreases with teacher experience. Less experienced teachers are also more likely to leave the profession than to move to another school, but the mobility to different occupations converges to school-to-school mobility for teachers with more than 8 years of experience. As far as intellectual assessment is concerned, turnover rate is stable across deciles of cognitive and non-cognitive scores, except for the bottom of the distributions, where it is larger for quits. Thus, it is the teachers with the very worst abilities that are more likely to leave the profession, potentially partly offsetting the documented by others decline in skills among inflowing teachers.

Figure 1. Teacher quality by student GPA



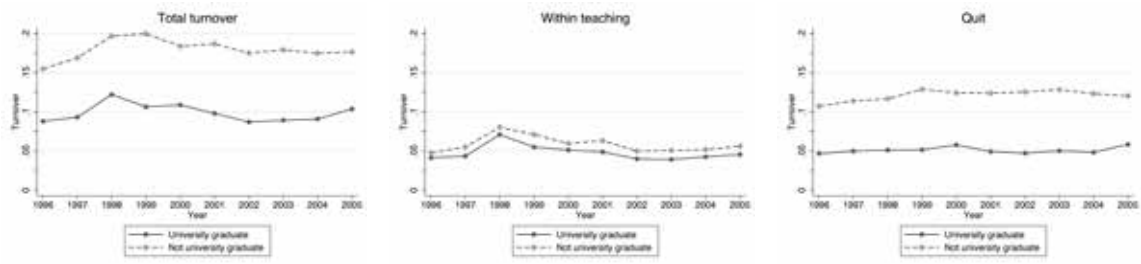
Note: Mean teacher quality (intellectual, university graduates, experience) and deciles of student GPA.

Figure 2. Teacher quality by share of minorities



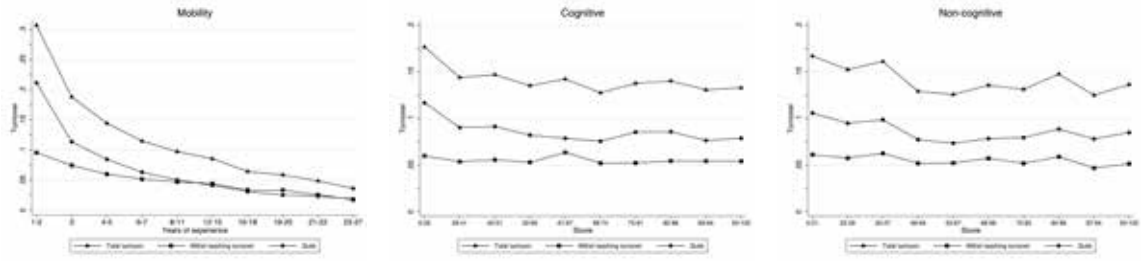
Note: Mean teacher quality (intellectual, university graduates, experience) and deciles of share of minority students at school.

Figure 3. Turnover over time for teachers with and without university degree



Note: Turnover measures over time for university (solid line) and non-university graduates (dashed line).

Figure 4. Experience, intellectual assessment and teacher turnover



Note: Turnover measures graphed for deciles of teacher experience, cognitive and non-cognitive test scores.

In sum, the descriptive evidence suggests that there is a substantial heterogeneity in teacher turnover with respect to teacher quality, irrespectively whether it is measured as

formal education, tenure in teaching or intellectual and behavioral assessments. There are also differences in teacher quality across school characteristics i.e., teachers of different quality tend to cluster at schools with particular observable characteristics.

Table 1 presents the descriptive statistics of variables used in the econometric analysis. Panel A presents three turnover measures, panel B presents teacher quality measures, panel C presents personal and pecuniary characteristics, while panel D presents average school-level characteristics. Total turnover rate, is at 12.5 %, which is lower than the overall turnover rate in all the occupations in Sweden (Edin et al., 2009). This could be driven by the fact that people who invest heavily in occupation-specific human capital (teaching) may have lower turnover rates in general. Although the quit rate in Sweden is larger than in Norway, these two countries share a common feature that the outflow from teaching is larger than the mobility within the profession. In the US registry data from Texas, Hanushek et al. (2004) find the opposite pattern (i.e., there is higher mobility within teaching rather than out of the profession). In panel B experience and university indicator are based on the whole sample of 525 076 observations from 2703 schools.[19] However, the intellectual assessment measures are based on the sample of native males, born prior to 1951 and drafted prior to 1970 with available data contributing 115 350 observations from 2628 schools. In the analyzed schools 67 % of teachers are university graduates with an average experience of 11.5 years and scores of 64 and 60 points on a standardized 0-100 scale for cognitive and non-cognitive assessments, respectively.

In Swedish schools 56 % of teachers are women, 6.8 % come from non-Nordic countries, 20.8 % are employed on temporary contracts and their average yearly earnings equals to 221 866 SEK. There is 15.6 % science, 13.8 % vocational and 6.6 % remedial education teachers.[20] The fraction of teachers employed in private schools during the studied period rose from around 2 % in 1996 to 10.5 % in 2005. The student-teacher ratio in full time equivalence, which can be seen as a proxy for school resources,

[19] Teacher experience is not available for all years, and thus, I use the predicted experience in the analysis. In particular, since the teacher registries date back to 1979 I explore this feature to construct the "in teaching predicted experience" variable. I create a panel of all teachers between 1979 and 2006 and link it to population enlistment data between 1985-2006 in order to obtain teacher's birth date. I then use all this information and tenure data provided in the later registries (since 1999 onwards) to construct the predicted measure of experience.

[20] Remedial education teacher (Speciallarare) works with students in need of special assistance concerning learning and development. Special education teachers focus on either language or mathematics.

is 11.5 and the average number of pupils is 574.[21] There is on average 8.3 % non-Nordic immigrants in Swedish schools. This number is larger than the one reported for Norway (Falch and Strøm, 2005).

Table 1. Descriptive statistics

Variable	Mean	Standard deviation
Panel A: Teacher turnover		
Total mobility	0.125	(0.331)
Within profession mobility	0.051	(0.220)
Out of profession mobility	0.074	(0.262)
Panel B: Teacher quality		
Experience	11.445	(7.778)
University graduate	0.674	(0.469)
Cognitive test score*	0.641	(0.244)
Non-cognitive test score*	0.603	(0.273)
Panel C: Personal and pecuniary characteristics		
Female	0.562	(0.496)
Foreign	0.068	(0.251)
Married	0.573	(0.495)
Upper secondary	0.437	(0.496)
Private	0.056	(0.230)
Science	0.156	(0.363)
Vocational	0.138	(0.345)
Remedial	0.066	(0.249)
Temporary	0.208	(0.406)
Workload	86.488	(23.273)
Log yearly earnings (1000SEK)	5.290	(0.586)
Panel D: School characteristics		
Share of girls	0.482	(0.100)
Share of foreign students	0.083	(0.086)
Student-teacher ratio in full time equivalence	11.511	(3.241)
Number of students/100	5.739	(4.574)
Students' parents income in 1000SEK	380.201	(96.397)
Student's percentiled GPA	48.175	(6.708)
N	525 076	

Note: mean values, standard errors in parentheses.
*N = 115 350

5 Main results

The estimates presented in this section correspond to the model outlined in section 3.3. I estimate a binary linear regression model with county-by-year fixed effects where the dependent variable equals to unity if the teacher leaves a particular school from year t to

[21] Number of students in lower-secondary school is measured as the sum of pupils attending grades 7 to 9 and it is provided in compulsory school registry by Statistics Sweden. Number of students in upper secondary school is measured based on the registry of students enrolled in grades 1 to 3 in upper secondary schools.

year t+1, and zero otherwise.[22] The results are presented in Table 2. Column (1) shows the raw correlation between the total turnover and teacher quality measured by university graduation and experience. Column (2) adds individual characteristics to the estimates from column (1). Column (3) provides estimates, including both individual and school level covariates. Column (4) adds yearly earnings to the specification from column (3). This allows me to understand if the differences in mobility by education and experience are driven by differences in earnings. At the same time, earnings are also a teacher quality measure, and thus the contribution of having higher education or more experience holding earnings constant is not trivial to interpret. Therefore, in the heterogeneity analysis I do not condition on earnings and use the specification from column (3).

Table 2. Main results using university education and experience. The dependent variable is equal to unity if the teacher changes job

Variables	(1) **Mobility**	(2) **Mobility**	(3) **Mobility**	(4) **Mobility**
University graduate	-0.040***	-0.005***	-0.004**	-0.002
	(0.002)	(0.001)	(0.001)	(0.001)
Experience	-0.009***	-0.004***	-0.004***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
R-squared	0.060	0.132	0.133	0.140
Observations	525,076	525,076	525,076	525,076
Personal characteristics		X	X	X
School characteristics			X	X
Log-earnings				X

Note: Standard errors clustered at school level (*** p<0.01, ** p<0.05, * p<0.1). All regressions include county-by-year fixed effects. Personal characteristics include: gender, immigration status, marital status, indicators for science, vocational and remedial specialization, indicator for temporarily employed, workload, indicators for upper secondary and private school teachers. School characteristics include: student-teacher ratio in full time equivalence, number of students and its square, indicator for schools with less than 100 students, share of girls and immigrants at school, mean percentiled student GPA and mean parental income. All regressions corrected for school mergers and dissolutions as well as for mobility in grades below 7th that teachers work with.

The results from columns (1) to (3) suggest that schools in Sweden do not lose university educated and experienced teachers, as both of the coefficients are negative and significant. An additional year of experience is associated with 0.4 to 0.9 percentage points (pp) lower mobility while holding university diploma is associated with 0.4 to 4.0 pp lower mobility depending on the specification. In columns (2) and (3) the coefficient on university education decreases about 10 folds in comparison to column (1) and these changes are virtually entirely driven by accounting for temporary employment status. This is likely due to the Swedish institutional setting, where permanent contracts are

[22] Specifications with only year, or only county, or only year and county, or using municipality instead of county fixed effects have also been estimated and yield similar results. Including school fixed effects removes some of the variation that is of interest in the heterogeneity analyses presented in this paper.

typically given only to teachers who have a university degree. When the earnings are added (column (4)) both coefficients decrease even more and the coefficient on university education becomes insignificant. This could mean that principals may have a scope for changing the mobility behavior of teachers of different quality through manipulation of monetary compensations and type of employment, but since this paper documents only descriptive associations there may well be other explanations to the observed pattern. If these job attributes can help retain experienced and educated teachers, then one would expect the estimates of teacher quality to be weaker when the controls are added into the model.[23]

Table 3. Main results using cognitive and non-cognitive assessment. The dependent variable is equal to unity if the teacher changes job

Variables	(1) Mobility	(2) Mobility	(3) Mobility	(4) Mobility	(5) Mobility	(6) Mobility
Panel A: Non-cognitive assessment unconditional on cognitive score						
Non-cognitive score	-0.039***	-0.014***	-0.014***	-0.008**	-0.011***	-0.007
	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
R-squared	0.011	0.116	0.117	0.129	0.122	0.131
Panel B: Cognitive assessment unconditional on non-cognitive score						
Cognitive score	-0.047***	-0.012**	-0.011**	-0.007	-0.003	-0.003
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
R-squared	0.011	0.116	0.117	0.129	0.122	0.131
Panel C: Both scores included						
Non-cognitive score	-0.033***	-0.013***	-0.013***	-0.008*	-0.010**	-0.006
	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Cognitive score	-0.041***	-0.010**	-0.009*	-0.006	-0.002	-0.002
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
R-squared	0.012	0.116	0.117	0.129	0.122	0.131
Observations	115,350	115,350	115,350	115,350	115,350	115,350
Personal characteristics		X	X	X	X	X
School characteristics			X	X	X	X
Log-earnings				X		X
University and experience					X	X

Note: Standard errors clustered at school level (*** p<0.01, ** p<0.05, * p<0.1). All regressions include county-by-year fixed effects. Personal characteristics include: marital status, indicators for science, vocational and remedial specialization, indicator for temporarily employed, workload, indicators for upper secondary and private school teachers. School characteristics include: student-teacher ratio in full time equivalence, number of students and its square, indicator for schools with less than 100 students, share of girls and immigrants at school, mean percentiled student GPA and mean parental income. All regressions corrected for school mergers and dissolutions as well as for mobility in grades below 7th that teachers work with.

It is a question of general interest, how individuals' intellectual capacities affect their decisions to change jobs. Table 3, in columns (1) to (4), re-estimates the specifications from Table 2, while substituting education and experience by cognitive and non-

[23] I have also estimated models for public schools only using monthly wages. The results are similar to these reported in column (4) i.e., they yield an insignificant and close to zero coefficient on university education and a negative 0.3 pp estimate on experience. Since the information on monthly wages is available only for public school teachers and the main results using both compensation measures are similar then the analyses in this paper use earnings. I have also estimated models where the two quality measures are included separately, and the conclusions do not change. These are available upon request.

cognitive test scores. In columns (5) and (6) I re-estimate specifications from columns (3) and (4) while controlling for education and experience. This allows me to understand the value-added from using the intellectual skills measures as compared to measures typically used in the literature. Panel A estimates association between non-cognitive skills and turnover unconditional on cognitive skills while panel B uses cognitive skills unconditional on non-cognitive skills. In panel C I include both measures simultaneously.

Results in columns (1) to (3) suggest a negative relationship between a propensity to leave current employment and both cognitive and non-cognitive skills with larger estimates for the former measure. This association is estimated to be between 4.7 and 0.9 pp depending on the specification and measure. In column (4) where I include earnings both coefficients decrease and only the estimate on non-cognitive skills remains significant. Estimates from column (5) suggest that controlling for teacher education and experience captures well the set of skills related to cognition, however, these measures are not so effective in terms of non-cognitive capabilities. Even when controlling for education, experience and cognitive skills I still find a significant and negative correlation of 1.0 pp between teacher mobility and non-cognitive skills. This is filtered out in column (6) where I also control for earnings but as it has been noted in the first paragraph of section 5 these results are not trivial to interpret given the fact that earnings itself is a measure of teacher quality.

Finally, I can only observe mobility if teachers leave their school from one year to another, however, it may be questioned whether this mobility is voluntary or not. In particular, there can be reshuffling of teachers between schools in municipality due to the fact that employment protection is based on an employment in municipality and not at the school (this naturally does not apply to privately owned institutions). It could also be the case that if one school has an opening for a teacher and there are other schools in the same municipality laying off teachers, there might be bargaining and reshuffling of teachers within the municipality. To address this issue I restrict the analysis to the sample of municipalities that never experienced reductions in the teacher stock by more than 5 % over the studied period.

Table A 1 and Table A 2 in the appendix present the estimation results using the sample described above and the specifications from Table 2 and Table 3, respectively.

The sample size is reduced around four-fold, however, the majority of the results using education and experience remain unchanged. Unlike in Table 3, however, the estimates on cognitive and non-cognitive skills in this restricted sample become mostly insignificant but very similar quantitatively. Thus, the lack of significance should rather be associated with increased standard errors due to reduction in sample size than with sample selection and changes in point estimates. Overall, these estimates suggest that the differences in mobility for teachers of different quality should not be driven by selective lay-offs when schools are down-sizing.

6 Heterogeneity analyses

So far the evidence suggests that schools in Sweden experience lower turnover rates of high skilled teachers, which is true both for the whole population and for the sample of schools where we shut down the potential for selective lay-offs. In the heterogeneity analyses, I give insights on how the high quality teachers match to the most disadvantaged schools. In particular, I analyze if teachers of different quality differ in the probability to leave schools with certain characteristics. For instance, high quality teachers may be more prone to leave schools with higher shares of minorities or schools with limited financial resources. The quality in Table 4 is measured by education and experience, while in Table 5 by cognitive and non-cognitive assessments.

Table 4. Heterogeneity analyses in education and experience. The dependent variable is equal to unity if the teacher changes job

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	**University graduate**		**Years of experience**					
	Yes	No	0-2	3-5	6-10	11-15	16-20	20+
Share of immigrants	-0.007	0.031	-0.009	0.031	0.029	0.037	-0.004	0.007
	(0.015)	(0.025)	(0.029)	(0.026)	(0.023)	(0.026)	(0.019)	(0.016)
GPA	-0.001***	-0.000	-0.001	-0.001***	-0.001**	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mean parental income	-0.000	-0.000	-0.000*	-0.000	-0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Private school teacher	0.040***	0.024***	-0.000	0.021**	0.022***	0.039***	0.031***	0.038***
	(0.006)	(0.008)	(0.010)	(0.009)	(0.007)	(0.009)	(0.010)	(0.009)
Student-teacher ratio FTE	-0.001***	0.000	0.000	0.001*	-0.001	-0.001	-0.002***	-0.001
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
R-squared	0.101	0.137	0.097	0.084	0.079	0.064	0.050	0.049
Observations	354,121	170,955	82,691	92,260	85,799	65,023	117,402	81,901

Note: Standard errors clustered at school level (*** p<0.01, ** p<0.05, * p<0.1). All regressions include county-by-year fixed effects. Personal characteristics include: gender, immigration status, marital status, indicators for science, vocational and remedial specialization, indicator for temporarily employed, workload, indicators for upper secondary and private school teachers. School characteristics include: student-teacher ratio in full time equivalence, number of students and its square, indicator for schools with less than 100 students, share of girls and immigrants at school, mean percentiled student GPA and mean parental income. All regressions corrected for school mergers and dissolutions as well as for mobility in grades below 7th that teachers work with.

University educated teachers tend to leave the private sector with higher likelihood, which works against the common perception that private schools cream skim the best teachers from the market (p-value: 0.028). It is also the highly educated for whom I find association between mobility and student quality (p-value: 0.000). Identical conclusion holds for school resources measured by student-teacher ratio in full-time equivalence. As far as experience is concerned, there is no significant positive correlation between mobility and working in private sector only among the least experienced teachers. The coefficient on student quality is insignificant also only for the least experienced individuals. Finally, unlike Hanushek et al. (2004) I do not find any relationship between the share of minorities at school and teacher mobility for teachers with different education or experience. This supports findings from Karbownik (2014) who found only scarce and heterogeneous evidence of increased teacher turnover in schools with high minority enrollment.

Table 5. Heterogeneity analyses in cognitive and non-cognitive assessment. The dependent variable is equal to unity if the teacher changes job

Variables	(1) **Cognitive score below median**	(2) **Cognitive score above median**	(3) **Non-cognitive score below median**	(4) **Non-cognitive score above median**
Share of immigrants	0.060	0.031	0.053	0.027
	(0.039)	(0.028)	(0.033)	(0.029)
GPA	-0.000	-0.001***	-0.001	-0.001**
	(0.001)	(0.000)	(0.000)	(0.000)
Mean parental income	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Private school teacher	0.026**	0.027***	0.014	0.038***
	(0.012)	(0.008)	(0.010)	(0.009)
Student-teacher ratio FTE	0.000	-0.001	-0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
R-squared	0.125	0.115	0.135	0.106
Observations	34,071	81,279	50,091	65,259

Note: Standard errors clustered at school level (*** p<0.01, ** p<0.05, * p<0.1). All regressions include county-by-year fixed effects. Personal characteristics include: marital status, indicators for science, vocational and remedial specialization, indicator for temporarily employed, workload, indicators for upper secondary and private school teachers. School characteristics include: student-teacher ratio in full time equivalence, number of students and its square, indicator for schools with less than 100 students, share of girls and immigrants at school, mean percentiled student GPA and mean parental income. All regressions corrected for school mergers and dissolutions as well as for mobility in grades below 7th that teachers work with.

In Table 5 I focus on the relationship between job characteristics and teacher turnover for teachers from different parts of intellectual assessment distribution. In particular, columns (1) and (3) report results for individuals below or equal to the median, while columns (2) and (4) report results for individuals above the median. Working in the private sector is equally associated with higher mobility among high and low cognitive

abilities teachers, yet it is only positively correlated with mobility of high non-cognitive ability teachers (p-value: 0.021). Furthermore, Table 5 again suggests no relationship between share of minorities and turnover. This is reassuring, as the disadvantaged schools in Sweden do not seem to lose their highly educated, experienced and skilled teachers. Finally, the negative association between mobility and student quality is confirmed for both above median cognitive and non-cognitive aptitude.

Since the 1990s there has been a heated discussion in the public debate and among researchers regarding allowing private sector to the public schooling system. Researchers assessed the influence of such changes on student (Ladd, 2002; Sandström and Bergström, 2005; Hsieh and Urquiola, 2006) and teacher (Hoxby, 2002; Hensvik, 2012; Jackson 2012) outcomes. Karbownik (2014) documents differences in turnover rates between private and public school teachers in Sweden. Furthermore, both Table 4 and Table 5 suggest that teachers of different quality experience differences in mobility depending on whether they work in private or public institution. Table 6 studies differences in mobility for different measures of teacher quality and different types of schools. In particular, columns (1) and (2) present differences between lower and upper secondary schools and columns (2) and (4) illustrate differences between public and private sector.[24]

[24] This distinction is of interest as Karbownik (2014) shows that although there is no relationship between minorities and turnover rate in lower secondary and public schools, it is significant and positive at the upper secondary level and in private schools.

Table 6. Teacher quality and school types. The dependent variable is equal to unity if the teacher changes job

Variables	(1) Lower secondary	(2) Upper secondary	(3) Public	(4) Private
Panel A: University education and experience measures				
University graduate	-0.005***	0.001	-0.003**	0.003
	(0.002)	(0.002)	(0.001)	(0.006)
Experience	-0.004***	-0.003***	-0.004***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)
R-squared	0.144	0.128	0.137	0.096
Observations	295,454	229,622	495,556	29,520
Panel B: Non-cognitive and cognitive measures				
Non-cognitive score	-0.023***	-0.001	-0.014***	0.012
	(0.006)	(0.006)	(0.004)	(0.017)
Cognitive score	-0.006	-0.010	-0.008	-0.019
	(0.007)	(0.007)	(0.005)	(0.019)
R-squared	0.132	0.113	0.122	0.103
Observations	58,567	56,783	107,020	8,330

Note: Standard errors clustered at school level (*** p<0.01, ** p<0.05, * p<0.1). All regressions include county-by-year fixed effects. Personal characteristics include: gender, immigration status, marital status, indicators for science, vocational and remedial specialization, indicator for temporarily employed, workload, indicators for upper secondary and private school teachers. School characteristics include: student-teacher ratio in full time equivalence, number of students and its square, indicator for schools with less than 100 students, share of girls and immigrants at school, mean percentiled student GPA and mean parental income. All regressions corrected for school mergers and dissolutions as well as for mobility in grades below 7th that teachers work with. Regressions in panel B exclude gender and immigrant indicator as intellectual assessment is available only for native males. Columns (1) and (2) exclude high school indicator from regressions while columns (3) and (4) exclude private school indicator from regressions.

Significant negative coefficient on university educated teachers is present only in lower secondary and public schools. In the former case, I can statistically reject the difference between lower and upper secondary school estimates (p-value: 0.055), however, in the latter case I am unable to reject the equality of estimates for public and private institutions (p-value: 0.306). These results might be driven by the fact that university graduates in public schools are different from those in private schools. Statistical investigation confirms that among university graduates those teaching in private schools differ significantly from those working in public schools as far as observable socio-economic characteristics are concerned. Nevertheless, even if these correlations are driven by selection into different sectors, they still should draw an attention of policy makers. The estimates on experience are similar for both school types and levels. Finally, I find strong and significant negative relationship between non-cognitive aptitude and mobility for lower secondary schools (p-value: 0.007). Similarly, I find a negative 1.4 pp association for public schools and I can reject that it is equal to insignificant but positive estimate for private schools (p-value: 0.086). Table 6 shows no differences in terms of cognitive skills.

The models used so far pool all destinations of teachers leaving the school together, however, there is research indicating that the correlations with teacher characteristics differ depending on the destination (Lankford et al., 2002). To investigate whether the relationship between teacher quality and teacher turnover depends on destination, I estimate the baseline specifications from Table 2 and Table 3 separately for mobility within teaching profession as well as out-of-teaching to a different occupation. Panel A reports estimates based on the specification from column (3) in Table 2, while panel B reports estimates based on the specification from column (3) in panel C in Table 3.

Table 7. Analyses by different destinations

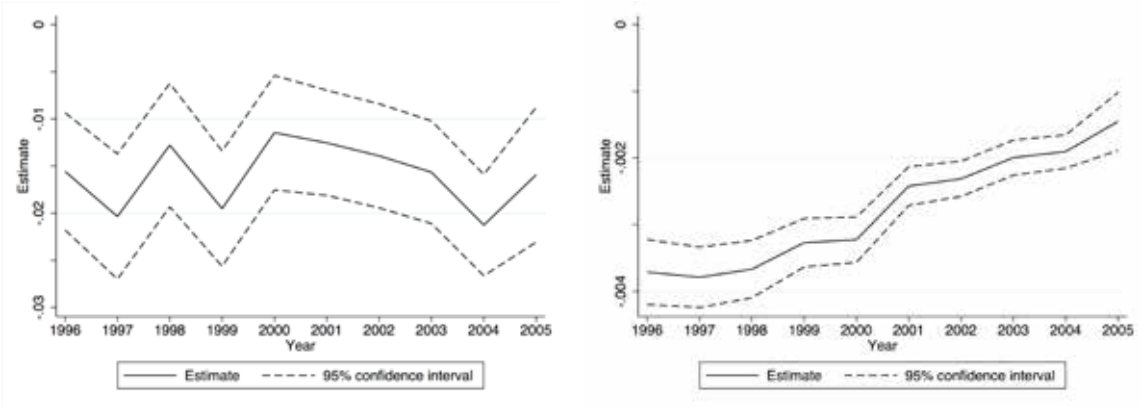
	(1)	(2)
Variables	**Within**	**Quit**
Panel A: University education and experience measures		
University graduate	0.013***	-0.017***
	(0.001)	(0.001)
Experience	-0.001***	-0.003***
	(0.000)	(0.000)
R-squared	0.032	0.108
Observations	525,076	525,076
Panel B: Non-cognitive and cognitive measures		
Non-cognitive score	-0.007***	-0.006*
	(0.003)	(0.003)
Cognitive score	-0.003	-0.006
	(0.003)	(0.004)
	0.027	0.099
	115,350	115,350

Note: Standard errors clustered at school level (*** p<0.01, ** p<0.05, * p<0.1). All regressions include county-by-year fixed effects. Personal characteristics include: gender, immigration status, marital status, indicators for science, vocational and remedial specialization, indicator for temporarily employed, workload, indicators for upper secondary and private school teachers. School characteristics include: student-teacher ratio in full time equivalence, number of students and its square, indicator for schools with less than 100 students, share of girls and immigrants at school, mean percentiled student GPA and mean parental income. All regressions corrected for school mergers and dissolutions as well as for mobility in grades below 7th that teachers work with. Regressions in panel B exclude gender and immigrant indicator as intellectual assessment is available only for native males.

University educated teachers are more likely to change jobs within teaching, than leave for alternative occupations. Similar pattern can be observed as far as experience is concerned, however, here both coefficients in the within and out-of-profession mobility regressions are negative with the one on quits being significantly larger. There is no significant relationship between cognitive skills and either type of mobility. I do, however, find a significant and negative association between non-cognitive skills and both mobility measures. These coefficients are of similar magnitude and cannot be statistically distinguished from one another. Thus, I conclude that better teachers are less likely to leave the profession and this is most pronounced in terms of formal education.

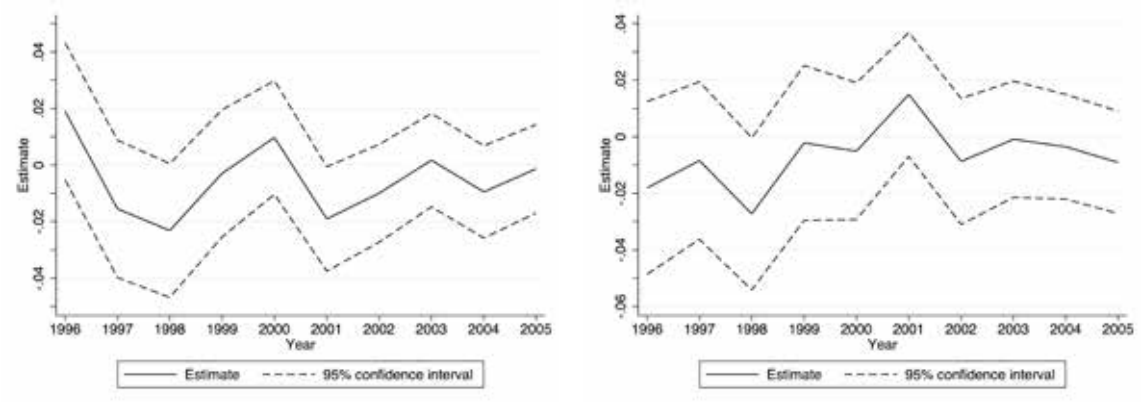
In their paper, Grönqvist and Vlachos (2008) document a declining quality of new teachers entering the profession in Sweden. In this research, I show that this decline in teacher quality is partly offset by a lower tendency for high-quality teachers (educated and experienced) to quit teaching. This tendency stayed roughly constant over time for university education and intellectual measures, with the former one being consistently negative and the latter two bouncing around zero (Figure 5 and Figure 6). It is, however, becoming less and less negative in terms of experience. In fact, between 1996 and 2005 the association between quitting teaching and experience decreased by a half. Finally in this paper, I focus on teacher quality conditional on the selection into teaching and show that among the pool of teachers who decide to pursue a teaching career it is the lower skilled ones who exit. My results do not give any insight about the total population of potential teachers, and in that sense cannot be directly compared to Fredriksson and Öckert (2007) who show that individuals with higher abilities do not enter teaching profession after teacher's training.

Figure 5. Leaving the profession and teacher quality - estimates over time



Note: Estimates from column (3) in Table 2 for each year separately. Left-hand side graph presents estimates on university education; right-hand side graph presents estimates on experience.

Figure 6. Leaving the profession and teacher quality - estimates over time



Note: Estimates from column (3) in panel C in Table 3 for each year separately. Left-hand side graph presents estimates on non-cognitive assessment; right-hand side graph presents estimates on cognitive assessment.

7 Conclusions

The contemporary literature on the teacher mobility lacked a detailed study relating turnover rates to teacher quality. Although high turnover rates may state a problem to some schools, principals (and students) are probably more concerned about the quality of teachers leaving the school. In particular, losing skilled teachers may be especially problematic for schools with many disadvantaged students. This paper attempts to fill in this gap in the literature on teacher turnover using unusually rich data on teacher skills for Swedish secondary school teachers covering years 1996/1997 to 2006/2007.

The results indicate that in Sweden schools do not seem to lose university educated and experienced teachers, and such teachers also do not leave the profession. In particular, teachers with high non-cognitive skills are less likely to change employers. This suggests that the drop in teacher quality documented by others is partly offset by lower tendency for high-quality teachers to leave the profession. I do not find any support for the common view that schools serving minority students experience higher turnover rates and outflow of high quality pedagogues. There is no evidence that a higher share of minority enrollment correlates positively with quits of high quality teachers. Finally, a somewhat speculative interpretation of the results on earnings is that it may be possible to influence teacher's mobility decision through changes in their monetary compensations or type of employment.

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Appendix

A1. Tables

Table A 1. Estimation results on a sample of municipalities with limited reductions in teacher stock. The dependent variable is equal to unity if the teacher changes job

Variables	(1) Mobility	(2) Mobility	(3) Mobility	(4) Mobility
University graduate	-0.041***	-0.010***	-0.009***	-0.007**
	(0.004)	(0.003)	(0.003)	(0.003)
Experience	-0.009***	-0.004***	-0.004***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
R-squared	0.060	0.137	0.138	0.146
Observations	129,275	129,275	129,275	129,275
Personal characteristics		X	X	X
School characteristics			X	X
Log-earnings				X

Note: Standard errors clustered at school level (*** p<0.01, ** p<0.05, * p<0.1). All regressions include county-by-year fixed effects. Personal characteristics include: gender, immigration status, marital status, indicators for science, vocational and remedial specialization, indicator for temporarily employed, workload, indicators for upper secondary and private school teachers. School characteristics include: student-teacher ratio in full time equivalence, number of students and its square, indicator for schools with less than 100 students, share of girls and immigrants at school, mean percentiled student GPA and mean parental income. All regressions corrected for school mergers and dissolutions as well as for mobility in grades below 7th that teachers work with. Sample reduced to municipalities, which do not experience reductions in teacher stock of more than 5 % over the studied period.

Table A 2. Estimation results on a sample of municipalities with limited reductions in teacher stock. The dependent variable is equal to unity if the teacher changes job

VARIABLES	(1) Mobility	(2) Mobility	(3) Mobility	(4) Mobility	(5) Mobility	(6) Mobility
Panel A: Non-cognitive assessment unconditional on cognitive score						
Non-cognitive score	-0.040***	-0.010	-0.011	-0.006	-0.008	-0.004
	(0.010)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
R-squared	0.013	0.125	0.127	0.140	0.131	0.142
Panel B: Cognitive assessment unconditional on non-cognitive score						
Cognitive score	-0.039***	-0.008	-0.007	-0.002	0.002	0.002
	(0.012)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
R-squared	0.013	0.125	0.127	0.140	0.131	0.142
Panel C: Both scores included						
Non-cognitive score	-0.035***	-0.010	-0.011	-0.006	-0.009	-0.005
	(0.010)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Cognitive score	-0.033***	-0.007	-0.005	-0.001	0.003	0.003
	(0.012)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
R-squared	0.014	0.125	0.127	0.140	0.131	0.142
Observations	28,874	28,874	28,874	28,874	28,874	28,874
Personal characteristics		X	X	X	X	X
School characteristics			X	X	X	X
Log-earnings				X		X
University and experience					X	X

Note: Standard errors clustered at school level (*** p<0.01, ** p<0.05, * p<0.1). All regressions include county-by-year fixed effects. Personal characteristics include: marital status, indicators for science, vocational and remedial specialization, indicator for temporarily employed, workload, indicators for upper secondary and private school teachers. School characteristics include: student-teacher ratio in full time equivalence, number of students and its square, indicator for schools with less than 100 students, share of girls and immigrants at school, mean percentiled student GPA and mean parental income. All regressions corrected for school mergers and dissolutions as well as for mobility in grades below 7th that teachers work with. Sample reduced to municipalities, which do not experience reductions in teacher stock of more than 5 % over the studied period.

A2. Details of sample construction

I construct the sample of lower and upper secondary school teachers for the school years 1996/1997 to 2006/2007. The information about teachers comes from the teacher registry and the analysis focuses on teachers working in grades 7-9 (lower secondary school) of compulsory education and in grades 1-3 (upper secondary school) of secondary education. The reason for restricting the analysis to these grade levels, is that I lack information on student characteristics for lower levels. Teachers who are on unpaid leave of absence or whose workloads are zero hours (i.e., they do not perform any pedagogical duties) are excluded from the analysis. Such teachers are treated neutrally in terms of mobility if they come back after the absence period to the same school. Similarly, I exclude teachers who are employed as principals, study counselors etc. In each year if a teacher has multiple entries in the registry, the observation with the highest workload is selected irrespectively whether it is at the same or at different schools.[25] The teacher registry is a high quality data set, that allows recovering information on school location (unique identifier), school ownership and type, teacher certification, workload, employment type (temporary vs. permanent), education and position. The construction of teaching experience is presented in the descriptive statistics section.

Teachers are grouped into either lower or upper secondary education and teachers working in grades 7-9 are recovered by merging the teacher registry to the pupil registry via unique school identifier. There exist schools with more grades covered under the same school identifier (i.e. 1-9 or 4-9) and one possible source of bias would be, for instance, relating teachers who work with students in grades 1-3 to school characteristics measured for students in grades 7-9. Since I have information about the grades in which teachers work I address this issue by excluding teachers coded as primary (grades 1-3) and middle (grades 4-6) school teachers. Such a procedure does not solve the problem completely as some teachers (arts or music) are not necessarily coded by grades. Thus, I may still include some miscoded teachers, however, the share of miscoded teachers is likely low. Nonetheless, each included school serves grades 7-9 and only turnover between such schools is considered at lower secondary level.

[25] The workload of teachers having multiple positions at the same school is not summed and the highest workload position is selected.

Teachers are then linked (using unique identifier) to population registry, which covers all individuals living in Sweden. The population registry is a high quality data set that allows recovering information on gender, marital status, age, family composition (using unique family identifier), immigration history, education and income. Income is measured as a gross salary plus income from business and self-employment plus any work-related allowances. Investment losses are not included, and thus, income is lower-bounded at zero. The analysis is restricted to teachers aged 25-58 years, to abstract from mobility driven by educational attainment and retirement decisions.

The earnings registry often contains multiple entries per individual, which reflect different sources of labor compensations but are uniquely identifiable based on establishment identifier. This poses linking problem for individuals with multiple entries as I may miss-assign earnings from different establishment to a particular school code. Since there is no direct link between unique school code and establishment identifiers, I create such a link using a mode rule. In particular, based on the individuals with only one record I define most often occurring establishment identifier for each school code. I then use this data to resolve matching of individuals with multiple earnings entries.

The students' characteristics are based on "school in" and "school out" pupil registries. The lower secondary school composition is based on outgoing students. The quality of students in lower secondary school is measured based on their 9^{th} grade outgoing grades. The measure is calculated for year t as a mean percentiled GPA from cohorts graduating in years t+1, t+2 and t+3.

The upper secondary school composition is based on all the students that are in a given school in a particular year. The quality of students in upper secondary school is measured based on their 9^{th} grade grades. The main advantage of using lower secondary school grades as a measure of upper secondary school quality is that it is largely exogenous to upper secondary school teachers. I match these students to their parents using unique family identifier and obtain the family level socioeconomic indicator i.e. mean parental income.

The enlistment registry covers period 1969 to 2006 and provides information on cognitive and non-cognitive assessments. Each of the parts that contribute to a final cognitive score is graded on 1 to 9 scale, and the final score is given in the same format.

To make the variable more continuous and utilize all the information I predict the final score using its separate components. I obtain a variable with mean 97.4 and standard deviation of 23.7. The non-cognitive score is based on 1 to 9 scale and each of the four contributing personality traits is rated on 1 to 5 scale. Here again, I utilize all this information and I predict the final score using separate components. Then, I percentile rank all the male, native individuals by type of assessment and year of draft. This procedure yields ranking of individuals in every test in every draft year for the whole tested population. The data is linked to teacher registry via unique personal identifier and scores are assigned to native, male teachers for whom the data is available.

Finally, having data with teachers and students I match the two using a unique school identifier. Naturally since the mobility itself is a lagged variable school year 2006/2007 is dropped from the analysis. The final sample includes 136 100 teachers and 622 453 person–year observations. I exclude the following observations from the sample: very small schools with number of teachers in full time equivalence less than 3 (5 170 observations), teachers that are below 25 years old (8 370 observations), teachers that are above 58 years old (82 298 observations), and schools with the number of students less than 15 (1 539 observations). The final sample consists of 121 580 teachers, 2703 unique schools and 525 076 person-years. Applying the intellectual assessment sample restriction further reduces the sample to 26 235 teachers, 2628 unique schools and 115 350 teacher-years.

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