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TEACHER SORTING, TEACHER QUALITY, AND STUDENT COMPOSITION: EVIDENCE FROM NORWAY

Hans Bonesrønning
Torberg Falch
Bjarne Strøm

Department of Economics

Norwegian University of Science and Technology
N-7491 Trondheim, Norway
www.svt.ntnu.no/iso/wp/wp.htm

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by
Hans Bonesrønning, Torberg Falch and Bjarne Strøm

Department of Economics, Norwegian University of Science and Technology, Norway

Abstract

Using panel data for Norwegian schools, we establish a two-equation supply and demand model for teachers with approved education. Taking into account nationally determined teacher pay and a strict teacher appointment rule, the data enable us to separately estimate supply and demand functions for certified teachers. The results clearly indicate that the student body composition, and in particular students belonging to ethnic minorities, influences both teacher supply and teacher demand. The implied negative relationship between excess demand for certified teachers and the share of minority students is likely to be important for teacher quality.

JEL classification: C30; I29; J45
Keywords: Teacher sorting; Teacher quality; School choice

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1. Introduction

School reform proposals with increased parental school choice as an important element is widely debated among economists and politicians. Possible student segregation effects of choice based reforms are central in this discussion. Much less attention has been given to the ways teachers sort themselves across schools. Conventional wisdom combined with some anecdotal evidence says that teachers emphasize the student body composition when deciding which school to attend [Ladd and Fiske (2001)]. Little scientific evidence exists that can confirm these conjectures. In the present paper, we undertake an empirical analysis on the relationship between teacher sorting and the student body composition. The major contributions of the analysis are that it seeks to separate the effects of student body composition on teacher supply and teacher demand, and how the composition affects teacher quality.

Several authors have examined the relationship between teacher quality and teacher pay in the US and routinely included variables intended to measure student composition such as the percentage of minority students, the percentage of students eligible for school lunch programs, and the poverty rate. These variables have merely been included as control variables to account for possible compensating wage differentials (see, e.g., Figlio, 1997, Ballou and Podgorsky, 1998 and Hanushek et al., 1999). Another, but closely related literature, initiated by Antos and Rosen (1975), directly focuses on the relationship between teacher wages and student composition. It derives implicit prices that teachers demand for teaching different types of students, that is, the extent of compensating differentials related to student composition. While both types of studies may reveal information on the relationship between teacher quality and student composition, the estimated equations are reduced form relationships and confound both underlying demand and supply forces in the teacher labour market. In addition, the assumption of perfect competition made in the literature on compensating wage differentials may be unrealistic in the teacher labour market given the existence of strong teacher trade unions on the supply side and political entities on the demand side.

We utilize a system with strong national restrictions on wage setting and hiring practices in Norwegian schools that allows us to separately identify the effects of student composition on the supply and demand for teachers without identifying the wage elasticities that would be

required in a conventional setting. In particular, we exploit the fact that teacher pay setting has been completely centralized combined with a legal rule that applicants without formal certification can only be appointed in a teacher position when no certified teachers apply or is willing to take the job. Using data on the number of fulltime-equivalent certified and non-certified teachers in Norwegian primary and lower secondary schools, we are able to separate the effects of student composition on teacher demand and teacher supply. In addition, we will argue that the number of certified teachers per teacher position, a ratio that is determined by supply and demand, is a reasonable measure of teacher quality. In estimating the effects of student composition on teacher supply, teacher demand, and teacher quality, we will address the issue of endogenous parental school choice and omitted variables by estimating several versions of the models, including models with fixed school effects and models using instrumental variables methods.

The plan of the paper is as follows. The following section describes how teacher supply and teacher demand is identified, and discusses the relevance of our measure of teacher quality. Section 3 depicts the empirical approach while section 4 describes the data. Section 5 presents the empirical results and section 6 offers concluding remarks.

2. Institutions and identification strategy

A fundamental problem in the literature on teacher quality is how to obtain separate identification of supply and demand of teachers. In this section we presents the institutional features that makes it possible to identify the shifts in teacher supply and demand generated by variations in student composition, without identifying the wage elasticities, which would be required in a conventional setting. In addition to describing our basic identification strategy, we will discuss how these institutional features can be used to construct a reasonable teacher quality measure simply based on supply and demand.

Public primary and lower secondary education in Norway (first through tenth grade), free of charge for the users, is the responsibility of the local governments. Norwegian local governments are multipurpose institutions, providing a large number of services, such as day

care and care for the elderly, in addition to education.[1] There are usually several public schools within each local government, and private schools are quite rare and do not represent a realistic alternative to public schools. Parental school choice between public schools for given residence is not allowed.

Two distinct features of the teacher labour market enable us to separately identify the supply and demand for teachers. First, in the period covered in this paper, teacher wages and workload were completely determined in central bargains between the teacher union and the central government. In a given year, the teacher wage was solely determined by the amount of formal education and teaching experience.[2] This national contract effectively prevents schools and school districts from using wage policy to attract teachers.[3] In addition, teacher workload, the number of instruction hours per full-time equivalent teacher, is regulated in the national contracts.

Secondly, in vacant teacher positions, the best-qualified applicant has to be appointed. By law, certified teachers shall be considered as better qualified than individuals without a teacher certificate.[4] Only in cases when it is impossible to hire certified teachers can and shall non-certified teachers be employed. According to the national contract, representatives of the teacher union must be informed prior to every hiring decision. In this way the union is able to closely monitor that the schools act in accordance with the rule, which have been one of the cornerstones in the teacher trade union policy.[5] Moreover, non-certified teachers can only be hired on short-term contracts up to one year. Thus, the employment of non-certified teachers

[1] Spending on primary and lower secondary education accounts for about 30% of total local government spending while spending on care for the elderly, preschool education, cultural services, infrastructure services and administration accounts for the rest.

[2] Many European countries have very centralized teacher wage setting; countries like France, Germany, Italy and the UK have basically a common wage schedule across schools, implying that an individual teacher is paid the same independent of the choice of school.

[3] There is one exception from the uniform wage. Some schools in the northern part of the country with particularly severe teacher shortage are allowed to pay about 10% higher wages, see Falch (2001). The empirical results in this paper are independent of the handling of these schools. Further, a limited amount of local wage flexibility was introduced in 2001.

[4] Teacher certification requirements are nationally regulated. There are mainly two ways to be certified. First, and most commonly, students who complete three or four years of study at special colleges (teacher colleges) are automatically certified to teach in primary and lower secondary schools. Second, individuals with university bachelor or master degrees with additional courses in education issues are certified to teach in lower secondary schools. In addition, individuals educated to take care of preschool children may obtain a certificate to teach in the lowest four grades if they take a special one-year course in pedagogy for young students.

[5] The local government is the formal employer of teachers, but hiring decisions are made by the school principal at each school and the teachers apply for jobs at the separate schools.

in a given school year reflects the state of the supply and demand of teachers that specific year.

While the regulations described may seem inefficient for economists, elements of such regulations are present in most developed countries. The important point in this paper is that the regulations can be used for identification. In our data, we have information both on the number of full-time equivalent certified teachers and the number of full-time equivalent non-certified teachers. Given the clear-cut rules, non-certified teachers can only be hired and observed in the data when it is impossible to attract certified teachers. Figure 1 illustrates the identification issue. The figure considers two schools with similar (inelastic) teacher demand, but different teacher supply. Given the centrally determined wage W^C, there is excess demand in school A. The supply is lower than the demand, and the school will not be able to fill all teacher positions with certified teachers. The school has to rely on non-certified teachers, and the teacher supply LS^{A*} is identified. In the data, the teacher supply is simply given by the number of full-time equivalent certified teachers *given* that the school has to employ non-certified teachers. For school B the supply is greater than the demand, the school does not employ non-certified teachers, and the supply is not identified.

Figure 1 here

School B in Figure 1 illustrates that teacher demand LD^{B*} is identified in schools not relying on non-certified teachers. In addition, if non-certified teachers can always be hired, and teacher demand is independent of the level of teacher supply as drawn in Figure 1, teacher demand is also identified at schools with excess demand simply as the total number of teachers (certified plus non-certified full-time equivalent teachers). Casual observations clearly indicate that it is always possible to hire non-certified teachers at the centrally determined wage level, and in the following we assume that supply of non-certified teachers is perfectly elastic over the relevant range. However, the assumption that labour demand is independent of the degree of excess demand may be an oversimplification. First, the wages of non-certified teachers are lower than the wages of certified teachers, and hence total teacher demand can be higher under excess demand because teachers are then cheaper at the margin. Second, if schools value certified and non-certified teachers differently, a single demand curve for teachers may not exist. If these arguments are important, it implies that for each observation we can only identify either supply or demand, whichever represents the short side

of the market. However, our understanding of the working of school policy in Norway is that local politicians to a large extent value schooling by teacher employment rather than by student achievement, which implies that demand does not respond to supply factors. Nevertheless, in the empirical analysis below we will investigate whether the size of the coefficients in the teacher demand equation depend on whether there is excess demand or not.

Our measure of teacher quality is the ratio between teacher supply and teacher demand. Define the quality Q as

$$Q = \frac{LS(X)}{LD(Z)} = h(X, Z) \tag{1}$$

where X and Z are vectors of variables influencing supply and demand, respectively, and which may have common elements. Q can be interpreted as the supply of certified teachers per teacher position and is related to the more familiar concept applicants per position used in Krueger (1988) and Holzer et al. (1991) in their analysis of job queues. When Q is high more efficient matches between employer requirements and employees are made compared to the situation where Q is low. Variation in this variable could then be seen as a measure of the variation in average teacher quality across schools. Utilizing data on certified and non-certified teachers, we observe Q when Q < 1, i.e., there is excess demand for teachers. While the determinants of teacher quality can be separated into supply and demand forces as sketched above, teacher quality can also be analysed directly as a sort of reduced form of the teacher labour market outcomes.

Using the share of the teachers that are certified as a measure of teacher quality warrant some discussion. The US evidence may suggest that formal teacher education is a poor measure of teacher quality.[6] It should be noted however, that a large part of this evidence comes from studies that apply the fraction of teachers with a master's degree as a measure of teacher education, and this measure may be too crude to capture the effects of non-certified teachers.

[6] Hanushek (1986) reports on 106 education production function studies that include measures of teacher educational level. Only 11 of these studies reveal statistically significant relationships between student achievement and teacher education, and five of these have a negative (i.e., "wrong") sign. Monk (1994) provides some evidence that teacher preparation is characterized by diminishing marginal returns or threshold effects, indicating that a measure based on certification may make more sense. Moreover, Monk finds that course work in pedagogy contributes positively to student learning, which is interesting because a fraction of the non-certified teachers in our sample have university education, but lack the required pedagogy courses. Goldhaber and Brewer (2000) find that students achieve at higher levels in mathematics when they have teachers who hold standard certification in mathematics, but on the other hand, students who have teachers with emergency credentials do no worse than students whose teachers have standard teaching credentials.

Moreover, most of the existing studies do not take the endogeneity of teacher characteristics into account.[7]

Ideally, one would like to test whether teacher certification has an impact on student achievement, while treating teacher qualifications as endogenous because teacher supply may be affected by the student composition. Such an analysis is beyond the scope of this paper. Based on data for Norway from the recent Program for International Student Assessment (PISA) undertaken by OECD, we have instead undertaken a simple correlation analysis. The PISA study was executed in 2000. Students in 32 countries were tested in reading, science and mathematics. Questionnaires of the participating students and their school principals include a large amount of information. We will focus on the proportion of the teachers that is certified as calculated by OECD, which corresponds to variable Q above. Table 1 presents some correlation measures. The simple correlation between Q and student achievement in reading, mathematics and science, as reported in the last row of Table 1, is 0.19, 0.16 and 0.28, respectively, and significant at the 5 percent level for all subjects.

Table 1 about here

To further address this issue, we estimate an equation with test score as the dependent variable and the share of certified teachers, school size and the student-teacher ratio as explanatory variables. The results from these specifications are reported in columns (1), (3) and (5) in Table 1. Achievement seems to be positively related to schools size, while the student-teacher ratio has a negative but clearly insignificant effect. Q has a positive effect in all cases, although the effect is significant only in mathematics. The magnitude of the coefficient implies that an increase in Q from 0.5 to unity is associated with an increase in achievement of 0.5 standard deviations in reading and science, and 0.8 standard deviations in mathematics. Columns (2), (4) and (6) in Table 1 report the results from a specification where the degree of certification is entered as a dummy variable taking a value of unity when Q=1. The results show that achievement is significantly higher in schools with Q = 1 than in schools with Q<1 in all subjects tested.

[7] Unfortunately, we do not have much systematic information on the characteristics of non-certified teachers in Norwegian schools. Information from the central register of teachers ("Statens sentrale tjenestemannsregister for skoleverket") for the school year 1999/2000 show that 31.6 (11.6) percent of the non-certified (certified) teachers was below 30 years of age. Moreover, seniority was much lower among the non-certified teachers compared to the certified teachers. These figures may suggest that a significant share of the non-certified teachers go to college or to another job after having served as teachers one or a few years.

The analysis in Table 1 should be seen merely as a multivariate correlation analysis and should not be taken as decisive evidence about the superiority of certified teachers relatively to non-certified teachers. But the results are consistent with the claim made above that Q is a reasonable measure of teacher quality.

Our teacher quality measure clearly illustrates that student composition may influence teacher quality via two different channels. To take a stylised example, consider a school where the supply of teachers initially equals demand. The school faces a large increase in the number of children from ethnic minorities qualified for special training according to the law. This will require more teachers and thus induce a positive shift in the demand curve. At the same time, if a higher share of such students is associated with less favourable working conditions for teachers, this may induce a negative shift in the supply curve. Since the school is faced with a fixed wage rate, this change in student composition will create excess demand for teachers, and non-certified teachers will in the Norwegian case fill the vacant teacher jobs.

3. Empirical specification of demand and supply

3.1. Teacher demand [8]

Specification of the empirical equations requires a discussion of the relevant characteristics of the Norwegian school system and the decision-making process on the allocation of educational resources.

The key variable determining teacher demand is the number of teacher education hours, denoted U, which is subject to several national regulations. Following the resource allocation formula used by the local governments, U is the sum of three different components. First, the local governments must provide a minimum number of teacher education hours at the schools, denoted UM, which is determined by enrolment and a rule on maximum class size (28 students per class in primary education and 30 students per class in lower secondary

[8] The demand for education services has been addressed in a large empirical literature, e.g., Barlow (1970), Romer et al. (1992), Hoxby (1996) and Falch and Rattsø (1999).

education).[9] UM is clearly beyond the control of the local governments and the maximum class size rule imply that it varies exogenously across schools. Second, the local governments are required to provide extra resources for children with special needs and children from ethnic minorities, usually taking the form as extra instructional support. Accordingly an amount of U is explicitly targeted to satisfy these requirements.[10] Finally, the local governments can freely allocate additional teacher education hours to the school in order to, e.g., divide classes into separate groups with separate teachers. A strict interpretation of the resource allocation formula would imply that teacher education hours targeted towards specific students corresponds to national regulations. However, in practice the local governments have substantial discretion on how to implement these national requirements. A local government may fulfil the national requirements by various support to students with special needs and from ethnic minorities. Thus, teacher education hours U in excess of UM must be seen as locally decided.

To abstract as much as possible from local government behaviour, we include time specific local government fixed effects in the model. Based on this framework, an empirical model of teacher demand measured in per student terms can be written (subscript i denotes school, j denotes local government and t denotes year):

$$\ln(LD/P)_{ijt} = \ln(LD/U)_t + \ln(U/P)_{ijt} = K^{LD} + \alpha_1 \ln(UM/P)_{ijt} + \alpha_2 SC_{ijt} + \alpha_3 Z_{ijt} + \lambda_{jt}^{LD} + \varepsilon_{ijt}^{LD} \quad (2)$$

Teacher demand (LD) per student (P) is decomposed into the number of teachers per teacher education hour (LD/U) and teacher education hours per student (U/P). LD/U can be interpreted as the inverse of the workload per teacher, which is centrally regulated, but differs

[9] UM is formally decided by the formula $UM=k_1P + k_2Cl$, where P is the number of students, Cl is the number of classes, and k_1 and k_2 are parameters decided by the central government. The number of classes is determined by enrolment and the rule on maximum class sizes.

[10] Students whose parents speak a foreign language have the right to additional language instruction until they have a good command in the Norwegian language. Resources targeted to these students usually take the form of instruction support for these students in ordinary classes. Further, a fundamental goal in the integration policy has been that physically, mentally and emotionally disabled students should go to the same schools and be in the same classrooms as ordinary students. According to the school act, such students shall be allocated extra resources based on individual education plans to be designed in an interaction between teachers, parents and specialists on disabled students. These resources usually take the form of additional instructional support in the classroom (provided by an extra teacher and/or teacher assistants) and additional equipment (computers, special learning materials etc.). There are no special formal certification requirements for these teachers. The extent and type of the extra resources depends on the type of disability the student possesses. For the more severe physical and mental disabilities, the classification of a student as special needs student is relatively straightforward. In the case of mild emotional disabilities the student has to undergo tests undertaken by psychologists and health specialists in order to get extra resources. The local government takes the final classification decision.

among the grades within primary and lower secondary education. We expect $\alpha_1>0$ due to the discussion above. SC describes the student composition and reflects the composition of the classes since all types of students are integrated in ordinary classes. In this paper, we will include the share of students from ethnic minorities and the share of students with special needs as measures of the student composition. Both variables are expected to increase the demand of teachers. The vector Z is a vector of other school characteristics, K is a constant, λ_{jt} are time specific local government fixed effects, and ε is a stochastic error term.

3.2. Teacher supply [11]

Two types of decisions of individuals certified as teachers determine teacher supply towards a specific school; whether or not to work as a teacher in the geographic area, and which school to join. The first decision presumably depends on the wage and working conditions the teacher can get in another job (or income as a non-participant in the labour market) relative to that in teaching, and the probability of getting another job. The decision to choose a specific school, conditional on having decided to participate as a teacher, depends on the wage and working conditions on that school relative to the wage and working conditions in other schools.

The textbook approach provides a useful point of departure. In the case of varying wage levels across schools, W_{ijt}, the outcome of the decisions of the teachers can be summarized in a supply equation:

$$\ln LS_{ijt} = K^{LS} + b_1 \ln W_{ijt} + b_2 \ln P_{ijt} + b_3 SC_{ijt} + b_4 Z_{ijt} + \lambda_{jt}^{LS} + \varepsilon_{ijt}^{LS} \qquad (3)$$

In a flexible wage world the effects of student composition can be identified from estimating a wage equation (the inverse of (3)) while conditioning on the number of teacher positions. This approach cannot be pursued in the present case, which is characterized by a rigid nationally determined wage rate. Wage differences will no longer inform teachers where to supply their labour. In traditional fixed-price models one usually takes the realized and observed quantity as determined by the short side in the market. According to this approach, when teacher

[11] Different components of teacher supply have previously been analyzed in various settings. Zabalza (1979) and Dolton and Mavromaras (1994) investigate determinants of entering and leaving the teaching profession, Hanushek et al. (1999) discusses teacher mobility, while Murnane and Olsen (1990), Dolton and van der Klaauw (1995) and Gritz and Theobald (1996) focus on the length of stay in teaching.

supply falls short of demand, the actual number of teachers employed is determined by the supply side, which is the only quantity observed. A main weakness regarding this approach is that the underlying behavioural supply relationships are assumed to be equal to those in the flex-price world, with the only exception that prices are non-flexible. A more realistic treatment would be to assume that in the absence of wage differences suppliers react to quantity signals. Teachers may take into account the probability and extent of rationing when deciding where to supply their labour.[12] An increase in resources to a school may increase the probability that an application will result in a job offer. This suggests that the higher are resources in a school, everything else constant, the higher is the number of teachers offering themselves for work in that school.

To capture the effect of quantity signals on supply behaviour, a quantity signal, F, is included in the supply equation instead of the wage signal.

$$\ln LS_{ijt} = K^{LS} + b_1 F_{ijt} + b_2 \ln P_{ijt} + b_3 SC_{ijt} + b_4 Z_{ijt} + \lambda_{jt}^{LS} + \varepsilon_{ijt}^{LS} \quad (4)$$

The share of minority students and the share of students with special needs can affect teacher supply through two channels. First, these types of students will, other things equal, require more effort from teachers than other children, which is likely to have a negative effect on teacher supply. Some US studies provide indirect evidence on this relationship for some student groups. Gritz and Theobald (1996) find that "teachers are less likely to remain in districts that enroll high percentages of minority students and students living in poverty, or in districts that are located away from urban areas" (p. 498). Using data on teacher transitions between Texas schools, Hanushek et al. (1999) provides strong evidence that teachers favour non-minority schools. Further, Ballou and Podgursky (1998) find that the lower the share of minority students in the school, the more school principals are satisfied with their teachers. Although the level of ethnic fragmentation in Norway is far from that in the US, this evidence suggests that the share of minority students has a negative effect on the supply of teachers.[13]

[12] Eaton and Quandt (1983) apply a similar approach in a macroeconomic model of labour supply.

[13] As it has become evident that individuals with minority background tend to have more social problems (higher rate of unemployment, lower wages, higher criminal rate and lower education), policies designed to integrate minority people into the society and provide better schooling opportunities have been high on the political agenda in Norway. Barth et al. (2002) provide evidence on the assimilation of immigrants into the Norwegian labour market.

In addition to this direct effect, a large share of students from ethnic minorities or with special needs induces the local government to allocate extra resources to the schools in various forms. According to national regulations in Norway, teachers of minority students or students with special needs have lower workloads (fewer hours in the classroom) than other teachers.[14] If these extra resources partially reduce the required effort by the teachers, the supply of teachers will increase. To identify the direct relationship between teacher supply and student composition it is important to include in the supply equation a variable representing the resource use at school. The same problem has faced researchers analysing the relationship between teacher wages and student composition. In some of these studies, the student-teacher ratio has been used as a measure of working conditions in the wage equation, e.g., Kenny and Denslow (1980), Eberts and Stone (1985) and Levinson (1988). The underlying argument is that teachers are assumed to favour schools with good working conditions; thus, reduced class size increases teacher supply and reduces equilibrium wages. Using the same type of argument, we include the number of teacher education hours per student, U/P, as a separate variable in the teacher supply equation. Higher U/P may imply smaller class size or larger possibilities to divide classes into smaller groups with separate teachers.

While the discussion above suggests that U/P should be included to capture variations in working conditions, U/P may also serve as a quantity signal, F, included in equation (4). We do not attempt to discriminate between these two mechanisms through which U/P affects supply, but both mechanisms imply that it is important to include this variable in order to obtain unbiased estimates of the effect of student composition since school resources are positively correlated with the measures of student composition used.

The time specific local government fixed effects included in (4) capture the effect of local private sector wages, labour market conditions, local living costs, the size of the local government budget, and other local government specific variables. A particular reason why this specification is warranted is that both observed and unobserved local government variables are likely to be among the determinants of the student composition in an area. For instance, minority parents may move into an area because of favourable economic conditions in that area. Including time-varying local government fixed effects effectively captures the effect of all such mechanisms. In addition, all national variables affecting the supply of

[14] To illustrate, according to the national contract a fulltime teacher instructing only special needs or minority students can obtain a maximum reduction in instructional hours; i.e. hours spent in the classroom, by 16 percent.

teachers such as national labour market conditions are effectively captured by this specification.

3.3. Endogeneity issues

So far we have implicitly assumed that student composition affects teacher demand and supply, and not the reverse. However, if the choice of location of parents responds to teacher quality, and thereby teacher supply and demand, student composition is endogenous in the teacher supply and demand equations. It may be argued that since teachers can move between schools at relatively low costs within a community, while students are able to change schools only by changing residence, the endogeneity problem is of less importance. However, many families move at least once when they have children, and the quality of schools may be an important determinant in their location decision. Further, since teachers' choice of school and parents' choice of residence may partly depend on the same unobserved variables, student composition may be correlated with unobserved factors at the school level. Since the number of minority inhabitants is relatively easy to observe, while information on the number of students with special needs in an area is much more difficult to obtain, it may be reasonable to assume that the endogeneity problem due to parental sorting is most relevant for the share of minority students. On the other hand, sorting of parents may be more of a problem with special needs students than minority students because special needs students are wealthier on average. A particular reason why the share of special needs students may be endogenous is the fact that the teacher plays an important role in the process of classifying potential students as special needs students or not. If certified and non-certified teachers have different propensities to classify a student, this variable may be correlated with the error term.

One strategy to reduce the possible bias due to parental sorting and omitted variables is to add school specific effects in the model, removing the effect of all school specific variables that are constant over time. However, this strategy also has some important limitations. First, if the variation in student composition is much larger between schools than within schools over time, which typically is the case, there may simply not be enough information left to obtain a school fixed effects estimator with a reasonable signal to noise ratio. Second, the school fixed effects approach implicitly assumes that the unobserved variables causing correlation between the error term and the student composition are constant over time, which may not be a realistic assumption.

The second strategy is to use an instrumental variable approach. We use a particular event in the immigration history to suggest a relevant instrument for the effect of the share of minority students. In the aftermath of the war in former Yugoslavia, a number of refugees from this area arrived in Norway and applied for political asylum. Most of these refugees were placed in provisional camps or given temporary residence throughout the country. The local governments were required to integrate school age children of the refugees in ordinary public schools. This means that some schools randomly experienced a sudden increase in the share of minority students. A particular feature of our data set is that we have information on the number of minority students with parents speaking the different languages in former Yugoslavia. If the distribution of refugees from former Yugoslavia across schools is uncorrelated with unobserved variables affecting teacher sorting, students with Bosnian or Albanian as their mother language can be used to generate valid instruments for the minority share.[15] Table 2 provides information on these students during the period 1992-1999 and shows that a major increase in the number of students from former Yugoslavia occurred in 1995-96.

Table 2 here

While certain events in the immigration history can be used to generate plausible instruments for the share of minority students, it seems much more difficult to find suitable instruments for the share of students with special needs. Since we already include time specific local government fixed effects, potential instruments must be school specific variables. One strategy is to investigate whether disaggregating the variable into different categories according to the severity of students' learning disabilities changes the empirical results. However, this approach only addresses the potential correlation between teacher characteristics and classification practices and not endogeneity generated through sorting of families across schools. While this is admittedly crude ways to handle the problem, other types of data, which are not available for us, have to be used in order to address this issue in a more satisfactory way.

Another variable that may be correlated with the error term in the supply equation is the resource use U/P because available resources and teacher supply potentially can be

[15] The number of students from former Yugoslavia with another mother language (Serbian and Croatian) is negligible.

determined by the same unobserved variables even though we control for all variation at the local government level. Our approach is to use the national regulations on minimum teacher education hours UM to generate exogenous variation in U/P. Since UM is beyond the control of local politicians and school leaders it is a natural candidate to choose as instrument. It should be noted that UM is generated in a manner very similar to the class size function following from the Maimonides' rule in Israel used as an instrument for actual class size in Angrist and Lavy (1999).

4. Data

The sample consists of all Norwegian primary and lower secondary schools for the school years 1995/1996 – 1999/2000, and is based on information collected by the Ministry of Education in *Grunnskolens Informasjonssystem*. The data include information at the school level of for example school type, schools size, the number of full-time equivalent teachers of different kinds, the number of classes, the number of teacher educational hours at school, and information on the student composition. While most of the information is available since the school year 1992/93, information on the number of teachers is only available from 1995/96.

In this paper we exclude schools not owned by local governments and schools labelled "special schools", accounting for 3 percent of the original sample. In the first year of the sample there is 3218 schools remaining in the sample. This number is reduced to 3184 in the last year in the sample, mainly because of closing of small schools, yielding a total of 16014 observations. In 172 of these observations some of the variables used in the analysis below are missing, The number of schools varies considerably between local governments. There are about 120 schools in Oslo, while about seven percent of the local governments have only one single school. At mean there are 7.3 schools per local government in 1999/2000.

Descriptive statistics of the variables used in the analysis is presented in Table 3. In about 46 percent of the observations, all teachers are certified, that is, Q=1. Thus, there is excess demand of teachers in more than half of the schools, for which we can measure teacher supply. The distribution of Q, conditional on Q<1, is shown in Figure 2.[16] Most schools with

[16] Cases with Q=0 (21 observations) are excluded from the analysis in order to use a logarithmic specification of the dependent variables.

excess demand have Q within 0.9-1.0, but quite a large number of schools have Q<0.9, at mean for schools with excess demand, Q is below 0.9.

Figures 2–5 about here

The distribution of school size is illustrated in Figure 3. Almost 30 percent of the schools have less than 60 students, while about 15 percent of the students are in schools with more than 400 students. The average school has 164 students and 14.6 full-time equivalent teachers, but the variation is large.[17]

Figures 4 and 5 display the variation in the measures of student composition. The average share of minority students is four percent, but almost 40 percent of the schools have no minority students. The distribution of the share of minority students, excluding schools without minority students, is shown in Figure 4. In most schools, the share of minority students is quite low, reflecting, to some extent, the central government's policy of spreading foreign refugees equally throughout the country. The percentage of students with special needs is about seven percent at mean, and the distribution is shown in Figure 5. While the share of minority students are larger in schools with excess demand than in schools without excess demand, the share of students with special needs are almost the same at average at these two types of schools.

5. Empirical results

In this section the estimated results for the teacher supply, the teacher demand, and the teacher quality equations are presented in Tables 4, 5 and 6, respectively. To simplify the presentation, the tables contain the results for a limited set of variables. The complete results for the baseline specifications are presented in Appendix Table A1. All results subsequently referred to in footnotes are available on request.

5.1. Teacher supply

Since teacher supply is only observed in the case of excess demand, a truncated or censored regression model is appropriate to recover a structural interpretation. Estimation results from

[17] Because there are many small schools, we will investigate the robustness of the empirical results with respect to school size.

such a model are presented below. There are, however, at least two important shortcomings of such models in our setting. Including fixed effects to control for omitted variables yields biased estimates because the fixed effects are not asymptotically independent of the other coefficients in non-linear models as first noted in the seminal paper of Neyman and Scott (1948). In addition, there are no obvious ways of how to handle endogenous variables.

The results from estimating the baseline model (4) by the Tobit specification using all schools are presented in column (1) in Table 4,[18] while the results using ordinary least squares on the sample of schools where teacher supply is observed are presented in column (2). The share of minority students has a significantly negative effect on the supply of certified teachers in both models. The results suggest that a school with no minority students has 17 log points higher supply of certified teachers than a school where all students belong to minorities. Thus, the share of minority students seems to be an important factor behind teacher supply variations across schools, and the quantitative impact is independent of estimation method.

Table 4 about here

On the other hand, the estimated supply effect of the share of students with special needs is positive, although not significant at five percent level in the Tobit specification. Compared to our prior expectations, the finding that school attractiveness seems to be positively related to the share of students with special needs is surprising. One possible explanation is that the variable capturing school resources per student, teacher education hours per student, is not sufficient to capture the actual change in allocated school resources associated with changes in the share of students with special needs. A rise in the share of students with special needs may also induce the local government to allocate extra resources in the form of assistants and technical equipment to the school. If these extra resources make the school more attractive for the teachers, in ways not measured in the model, this will bias the estimated effect of special needs students on teacher supply upwards. In addition, the propensity to classify children to have special needs may be linked to the credential of the teachers. Since the initiatives to classify special needs students can come from the individual teachers, this may be more

[18] The model includes local government – year specific effects which may bias the coefficients in the Tobit model due to few observations used to estimate each fixed effect. To get an indication on the magnitude of this bias, the model has also been estimated including only time invariant local government fixed effects. In this case 36.4 observations are on average used to estimate each fixed effect in contrast to 7.3 observations in the baseline model. The results were almost identical to those reported in Table 4, for example the effect of the minority share was -0.172 with the same standard error.

pronounced in classes with certified teachers than in classes with non-certified teachers. This motivates the classification of students with special needs with respect to learning disabilities done below. Nevertheless, taken at faced values, the result implies that teachers handling students with special needs are overcompensated through the implied workload reduction since teachers instructing special needs students spend less hours in the classroom than other teachers. Unfortunately, no information is available on the actual workload reduction besides the maximum amount of 16 percent.[19]

The measure of school resources, the number of teacher education hours per student, has a strong positive effect. The results in column (1) indicate that ten percent increase in the number of teacher education hours per student increases the supply of certified teachers per student by 7.5 percent.

Since the effect of the variables of interest are similar at least in economic terms using OLS on the sample of schools with observed supply and using the Tobit specification on all schools, it seems that the sample with observed supply is a reasonable representation of the population of schools. Thus, we will use the sample of observed supply to investigate whether the baseline results are biased due to omitted variables and endogenous variables. As outlined in section 3.4, the student composition variables may be correlated with the error term even if the effect of all school district variables are taken care of by time specific local government fixed effects. To reduce the potential biases resulting from such correlations, column (3) in Table 4 presents the results when school fixed effects are added to the baseline model. While reducing the estimated size of the effect of student composition somewhat, the effect of the minority share is still significant at ten percent level. The effect of the share of students with special needs, however, is still positive, but now clearly insignificant. It is worth noting that in this specification, the student composition effects are identified solely by within school variation over time and hence the signal to noise ratio may be low.

While the above results are suggestive on the student composition impact on teacher supply, the estimated effects may nevertheless suffer from bias due to correlation between the error

[19] If the actual workload reduction is about 10 percent, and if teacher supply is unitary elastic with respect to workload reduction, the workload reduction can only account for about half of the estimated positive effect of special needs students on teacher supply. On the other hand, using the same assumptions for the effect of minority students, implies that in the absence of workload reduction, an increase in the share of minority students from zero to unity would lead to about 27 log points increase in teacher supply, suggesting that the current policy accounts for roughly one third of the apparent net costs on teachers.

term and the regressors. To further handle the potential endogeneity of the minority share, we estimate the model by two stage least squares as discussed above. Column (4) in Table 4 presents the results when the share of minority students is instrumented by the share and number of students with Bosnian and Albanian as their mother language. The test for overidentifying restrictions provides evidence that the instruments are valid, even though this test is weak when the source of the variation in the instruments is similar as in our case. The first-stage results presented in Table A2 in the appendix suggest that the instruments are able to explain a substantial proportion of the variation in the minority share.[20] In this model, the numerical size of the effect of the share of minority students is higher than when estimating the model with OLS. Since parental mobility is expected to bias the OLS–result of the minority share away from zero, this indicates that if the OLS–result is biased, it is due to omitted variables. However, the difference between the OLS–results and the 2SLS–results is only about one standard deviation.

The results for the model where both the share of minority students and teacher education hours per student are instrumented are presented in column (5) in Table 4, where the centrally decided minimum level of teacher education hours is included as an instrument for total teacher education hours as motivated in Section 3.4. This model formulation actually strengthens the estimated negative effect of minority students on teacher supply. Because the effect of resource use can be seen as identified by a discontinuity rule, it is important to adequately control for the effect of the variable that generates the discontinuity as argued by Angrist and Lavy (1999). Because we use data at the school level and not the grade level in the analysis, it is impossible to fully control for enrolment by using the rule underlying the instrument as in Angrist and Lavy (1999). But including a full set of dummy variables for school size does not alter the results reported in Table 4.[21]

[20] Using only one of the instruments yields similar results. Using only the share (number) of students with Bosnian and Albanian as their mother language, the effect of the minority share is -0.188 (-0.237) and significant at five percent level. The same holds for the teacher demand and teacher quality models reported below. One may be concerned that the distribution of the refugees only was random in 1995, the year of the large inflow (see Table 2), even though the mobility of the refugees are low the first few years in the country. Using only the 1995 distribution as instrument, the effect of the minority share is -0.195 and significant at five percent level. Interacting the instruments with year dummies does not alter the result. This indicates that it is the initial distribution that matters. To further investigate the robustness of the results, we added school fixed effects to the model. As expected, this made the effect of minority share small and insignificant since the share of Bosnian and Albanian students shows much less within–school variation than the minority share itself.

[21] In a model with dummy variables for the number of students (782 variables), the effect of the minority share is equal to –0.32 and highly significant.

As discussed in Section 3.4, it is very hard to find any compelling school specific instruments for the share of students with special needs. One simple approach is to split the students with special needs into the three different categories of the severity of their learning disabilities as reported in the original data. The data divide the students into categories for major, moderate and mild learning disabilities.[22] The model in column (6) in Table 3 clearly indicates that the positive supply effect of special needs students does not depend in any systematic way on the severity of the learning disabilities they possess.[23] The fact that the positive effect is at least as strong for the major disabled as for the mildly disabled suggests that the classification policy does not depend in any systematic way on teacher characteristics since systematic classification should be of little importance for the major disabled. Using the share of students with major learning disabilities as an instrument for the share of special needs students actually increased the estimate of special needs students, although the effect was imprecisely estimated.

Since there are no national regulations requiring special needs students to be instructed by certified teachers, it is unlikely that the positive effect of the share of students with special needs is driven by some mechanical relationship between special needs students and certified teachers. Another possible explanation of the positive effect of special needs students is that families with disabled children are more likely to sort themselves across schools than other families and that they selectively choose schools with generous treatment of special needs students. If teachers also for some unobserved reason systematically choose such schools, this could lead to a spurious positive effect. Fixed school effects should capture much of this sorting behaviour, and may explain why the effect of the special needs share is smaller in the model including such effects. Summing up, it is fair to conclude that it is difficult to obtain robust results or compelling interpretations regarding the effect of the share of students with special needs on teacher sorting. On the other hand, the effect of the share of minority students seems to be robust to how the share of students with special needs is handled.[24]

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[22] The categories are defined by the level of extra resources allocated. Students with major learning disabilities, measured both in physical and mental terms, is defined as those receiving 360 or more extra teacher education hours per year. Students with moderate and mild learning disabilities receive 101–360 and less than 101 extra teacher education hours, respectively.

[23] Estimating the model only including the share of students with major learning disabilities, the effect of this variable is equal to 0.22 and significant at five percent level, while the other variables in the model have practically equal effects as in the models in columns (2) and (6) in Table 4. We have also estimated a model completely excluding all variables measuring students with special needs, yielding unchanged effects of the other variables.

[24] Various robustness checks of the baseline model have been undertaken. First, to check for the sensitivity of the results with respect to outliers, we estimated the model excluding schools with extreme values of the student

While the results above indicate that student composition does seem to affect the sorting of teachers between schools within school districts, it is of interest to know whether such sorting also takes place between school districts. To investigate this issue, column (7) in Table 3 reports the results from an aggregated model using time-variable local government weighted means of the variables.[25] Within this model, only variation across local governments is utilized, and the effect of student composition is much smaller and insignificant. One possible interpretation is that teachers respond to variation in the share of minority students by moving mainly within, and not between school districts. Obviously, local governments do not necessarily correspond to job and residence markets.[26] Nevertheless, teachers moving between local governments need to change residence to larger extent than teachers switching schools within a local government. However, another possibility is that the between district variation in student composition is simply too low to allow identification of the impact using data aggregated to the district level.

5.2. Teacher demand

As discussed in Section 2, teacher demand is observed in the case of excess supply, while interpreting the total number of teachers in the case of excess demand as teacher demand is only valid under certain assumptions. Column (1) in Table 5 contains the estimation results for the variables of interest using Tobit on the whole sample, while column (2) contains the

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composition variables. As Figures 4 and 5 show, in some few schools all students belong to minorities and in some schools all students have special needs. Excluding these schools from the sample gave only minor changes in the baseline results (the effect of the minority share and the share of students with special needs are equal to –0.16 and 0.14, respectively). Second, as Oslo is the far largest city in the country and also has a share of minority inhabitants far above the other parts of the country, we estimated the model excluding Oslo from the sample. This did neither affect the results (the effect of the minority share and the share of students with special needs are equal to –0.18 and 0.21, respectively). Third, because there are a large number of small schools, one may be concerned that small special schools drive the results. By estimating the model using only schools with more than 350 students (1023 observations), the effects of the minority share changes little (the effect of the minority share and the share of students with special needs are equal to –0.16 and 0.09, respectively, and the former effect is significant at five percent level). Finally, one may be concerned that Q is marginally below unity in some cases simply because of noise. In a model only including schools with Q<0.9 (2910 observations), the effect of the minority share is –0.18 and significant, while the effect of the share of students with special needs is 0.15 and insignificant.

[25] Notice that when the data are aggregated to the local government level, Q<1 even though there is excess demand only in the smallest school in the local government. In addition, given that the supply relationship is truncated in the data and thereby non-linear, it can in principle not easily be aggregated across schools. To exclude local governments with a very minor use of non-certified teachers, the model in column (7) in Table 4 are based on a sample where the mean of Q is less than 0.98. To take account of local labour market conditions and local fiscal conditions, we included county dummies, log of district population size and the share of population living in rural areas as additional regressors in the model.

[26] Statistics Norway has recently constructed 90 job market areas based on information of worker commuting from the 1990 Census. On average, these areas consist of 4-5 local governments.

OLS results for the model estimated on the excess supply sample only. In column (3) the OLS-results for the model using the whole sample are shown. The share of minority students has a strong positive effect in all specifications. Comparing a school with no minority students with a school where all students belong to minorities, the latter school demands between 60 and 90 log points more full-time equivalent teachers. The share of students with special needs has an even stronger effect. These results are in accordance with the national regulations on school resource allocation discussed in Section 3.1, which implies extra instructional support for these student groups. In particular, the results show that the effect of the student composition measures is well above the pure effect of reduced workload for teachers instructing these students.

Table 5 about here

The minimum teacher education hours per students has a strong positive effect. This variable capture to a large extent school size because the minimum hours are highly negatively related to the number of students.[27]

All coefficients in the Tobit model are larger than in the OLS models. When we in the following estimate linear models, the results may be seen as conservative estimates. The main assumption underlying the estimated model in Column (3) in Table 5 is that central regulations on class size and educational hours per grade, combined with support for certain student categories, are the main determinants of teacher demand. A potential objection is that the number of teachers hired may depend on teacher quality and hence on teacher supply. If this is the case, one is only able to identify demand for certified teachers when there is excess supply. A simple way to address the importance of this issue is to compare the parameters of interest between the models in column (2) and (3) in Table 5. It turns out that the estimated parameters are very similar in economic terms across the models.[28] This indicates that the

[27] Even in the present specification of the model, there is a negative effect of the number of students, implying some economics of scale. Excluding the minimum teacher education hours from the model, all variables have the same effect except the number of students which gets a much larger effect in absolute term In this model specification, ten percent increase in the number of students increases the number of full-time equivalent teachers by 8.1 percent, which reflects substantial economics of scale in schools. It should be noted that this result only applies to schools with more than 60 students because dummy variables are included for schools below this size.

[28] Even though the variables of interest seem to have equal effects in economic terms, they differ in statistical terms. A formal test of the null hypothesis of equal effects of the parameters reported in column (2) and (3) in Table 5 is rejected by an F-test at one percent level. Equal effects of all variables of the model are also strongly rejected by an F-test, which should be of no surprise since the model includes 2200 parameters.

demand function for certified teachers is identified not only in the case of excess supply, but also when the schools have to hire non-certified teachers.

In the model with fixed school effects, presented in column (4) in Table 5, the effect of student composition clearly drops in numerical value. While this may indicate an upward bias in the previously estimated effects, another possibility is that it takes some time for schools to respond to short-term changes in student composition. Although the use of fixed school effects may reduce the potential problems with correlation between the student composition variables and the error term, we also investigate this issue by estimating the demand model with the minority share instrumented. The results, shown in column (5) in Table 5, are qualitatively similar to the baseline model.[29] The low p-value on the test for overidentifying restrictions, however, suggests that the sum of Bosnian and Albanian students has a separate effect on teacher demand. This is not surprising because these students, who arrived directly from an area with massive violence, are likely to require a closer following up than other minority students.

As in the analysis of teacher supply, we lastly split the students with special needs into three categories. As expected, the different categories have significantly different impacts on teacher demand. Students with major, moderate and mild disabilities demand 167, 90 and 44 log points more teachers, respectively, than students without special needs. Notice that the effects of the other variables in the model are basically unchanged compared to the baseline specification.

5.3. Teacher quality

The supply and demand analyses give clear predictions on how different variables influence excess demand, which is our measure of teacher quality Q. Nevertheless, a separately estimated model for Q is instructive because this approach may hinge to a smaller degree on identification via the institutional set-up as described in Section 2. Q is a truncated variable, and Deaton (1997) and Angrist (2000) argue that the choice of estimation method in this case depends on how one wants to interpret the estimated results. If one is interested in the share of certified teachers, which is what Q actually measures, it is appropriate to use linear methods

[29] Estimating this model only using observations of excess demand, the effect of the minority share, special needs share, and minimum teacher education hours per student are equal to 0.77, 0.93 and 0.69, respectively, close to the results reported.

because this variable cannot exceed unity. The mass point of Q=1 in this case comes about because it is impossible that a ratio exceeds unity, and estimation of an average effect requires that both observations where Q=1 and Q<1 are included in the analysis. On the other hand, if Q is interpreted as the supply of certified teachers per teacher position, as discussed in Section 2, the index of teacher quality will exceed unity in the case of excess supply. There is censoring of the data, and it is appropriate to use the Tobit method. In this case, changes in the student composition will not only influence teacher quality in schools with excess demand, but also in schools with excess supply. Moreover, a reasonable assumption may be that schools that are able to hire many certified teachers also are able to hire such teachers with other valuable characteristics. This suggests that the variation in the ratio of certified to total number of teachers understates quality variation. Thus, the average effect of student composition will be stronger when Q is interpreted as a censored variable than when Q is strictly interpreted as a ratio. A conservative strategy in this case is to rely on linear estimation methods, which is our basic approach in the following, but for completeness we also report the results from a Tobit specification.

Table 6 about here

The results of several specifications of the teacher quality function are reported in Table 5. Column (1) presents the baseline model, estimated by OLS and with the student composition measures entered as exogenous variables. The effect of the minority share is significantly negative with a coefficient of –0.17, close to the effect in the supply model. To get an idea of how much of the variation in teacher quality this does explain, the result implies that one standard deviation decrease in the share of minority students leads to an increase in teacher quality by approximately 0.15 standard deviations. This is an average effect over both schools for which it is possible to change Q and schools where Q=1. The effect of the share of students with special needs is close to zero, indicating that the demand and supply effects are of qualitative equal magnitude. Regarding the effect of minimum education hours, the effect is negative, indicating that the effect is larger on demand than on supply.[30]

[30] Restricting the sample only to schools with above 350 students (1575 observations) does not alter the baseline results; the effects of the minority share, the share of students with special needs, and minimum teacher education hours per student are equal to –0.25, -0.02, and -0.05, respectively, and the former effect is significant at five percent level

Column (2) in Table 6 extends the model by including school fixed effects. While the effect of the minority share decreases in numerical terms, the effect is still sizeable and significant. In this specification, the effect of the share of students with special needs is significantly negative. Column (3) shows the 2SLS results when the share of minority students is instrumented. The estimated effects are fairly close to those obtained using OLS, and the test of overidentifying restrictions suggests that the instruments are valid. Column (4) in Table 5 presents the results from a model where the share of special needs students is separated in three groups as before. None of the groups alter teacher quality significantly.

Finally, Table 6 reports the results from estimating the model by the Tobit specification. As expected, the effects of the measures of student composition increase when Q is interpreted as a censored variable instead of being naturally truncated. A possible interpretation is that reduced minority share increases the number of applicants and thereby increases teacher quality not only in schools with excess demand which can increase the share of certified teachers, but also in schools with excess supply because they can choose teachers from a larger pool. In this model, the effect of the share of students with special needs is negatively significant, indicating that the positive demand effect dominates the positive supply effect.

It is of interest to compare the estimated relationship between teacher quality and student composition with the relationship implied by the estimated supply and demand equations above. The predicted effect on minority share (special needs share) based on the fixed school effects specifications is –0.22 (-0.13), compared to the estimate of -0.12 (-0.11) in the reduced form teacher quality model in Table 6.[31] Larger predicted effects than estimated effects is consistent with the argument above that linear models of teacher quality yield conservative estimates because the prediction is made from models with continuous dependent variables.

6. Concluding remarks

Educational markets are characterized by sorting. While most researchers have been occupied with the residential sorting that takes place on the demand side of the market, the current

[31] When making these calculations we assume that the effect of student composition on teacher education hours per student is equal to the effect on teacher demand per student.

paper focuses on sorting on the supply side. Sorting on the supply side is determined by the interaction between supply and demand in the teacher labour market.

Our empirical analysis departs from an analytical framework that focuses on teacher supply directed towards specific schools, and the teacher demand generated by the same schools within a rationed teacher labour market. The data, which allow separate estimations of the supply and demand equations, come from the Norwegian elementary school system, characterized by a common pay schedule and a high degree of national regulation of local governments. The empirical analysis reveals that certified teachers prefer schools with native students, and that the demand for certified teachers is positively related to the shares of students from ethnic minorities and the share of students with special needs. Our study also suggests that teacher sorting mainly takes place within communities.

The econometric analysis addresses the question that teacher demand and supply responses to student characteristics may trigger residential sorting by using the large inflow of Albanian and Bosnian refugees in the mid-nineties to generate instrumental variables for the share of students from ethnic minorities. The result that supply of certified teachers is decreasing in the share of minority students seems robust to the use of IV-methods. Further, the results are qualitatively the same when a fixed school effect specification is estimated. Using excess demand for teachers as a measure of teacher quality, the results also show that teacher quality is systematically lower in schools with large shares of minority students.

The evidence of sorting in the teacher labour market casts doubt on the effectiveness of a completely centralized wage-setting system. For several decades, individual Norwegian schools and local governments have not been allowed to use the wage mechanism to improve the quality of the teachers. This is likely to have two different types of costs. First, if the use of non-certified teachers does not compensate for the lower supply of certified teachers in quality terms, and if teacher quality is important in education production, minority students receive lower quality education than native students. This quality reduction adds to the other costs of providing education in schools with high minority share. Second, schools with excess supply may be in the situation of paying a higher wage than necessary for a given teacher quality.

Another policy conclusion to be drawn from our study is that the possibility of teacher sorting should be taken into account in the present debate on parental school choice. If increased parental school choice increases student segregation along ethnic lines in the first place, unwanted effects on the distribution of education benefits and human capital can be reinforced through the teacher sorting mechanism identified in this paper – at least if policy makers choose to stick to a fixed wage structure.

References

Angrist, J.D., 2000. Estimation of limited-dependent variable models with dummy endogenous regressors: Simple strategies for empirical practice. NBER Technical Working Papers 248.

Angrist, J.D., Lavy, V., 1999. Using Maimonides' rule to estimate the effect of class size on scholastic achievement, The Quarterly Journal of Economics 114, 533–575.

Antos, J.R., Rosen, S., 1975. Discrimination in the market for public school teachers, Journal of Econometrics 3, 123-150.

Ballou, D., Podgursky, M., 1998. Teacher recruitment and retention in public and private schools, Journal of Policy Analysis and Management 17, 393-417.

Barlow, R., 1970. Efficiency aspects of local school finance, Journal of Political Economy 78, 1028-1039.

Barth, E., Bratsberg, B., Raaum, O., 2002. Local unemployment and the earnings assimilation of immigrants in Norway. Memorandum no. 19/2002, Department of Economics, University of Oslo.

Deaton, A., 1997. The analysis of household surveys. A microeconometric approach to development policy. The International Bank for Reconstruction/The World Bank and the John Hopkins University Press Baltimore, ML.

Dolton, P., Mavromaras, K.G., 1994. Intergenerational occupational choice comparisons: The case of teachers in the UK, Economic Journal 104, 841-863.

Dolton, P., van der Klaauw, W., 1995. Leaving teaching in the UK: A duration analysis, Economic Journal 105, 431-444.

Eaton, J., Quandt, R.E., 1983. A model of rationing and labour supply: Theory and estimation, Economica 50, 221-233.

Eberts, R.W., Stone, J.A., 1985. Wages, fringe benefits, and working conditions: An analysis of compensating differentials, Southern Economic Journal 52, 274-280.

Falch, T., 2001. Estimating the elasticity of labor supply utilizing a quasi-natural experiment. Mimeo, Norwegian University of Science and Technology.

Falch, T., Rattsø, J., 1999. Local public choice of school spending: Disaggregating the demand function for educational services, Economics of Education Review 18, 361-373.

Figlio, D.N., 1997. Teacher salaries and teacher quality, Economics Letters 55, 267-271.

Goldhaber, D.D., Brewer, D.J., 2000. Does teacher certification matter? High school teacher certification status and student achievement, Educational Evaluation and Policy Analysis 22, 129-145.

Gritz, R.M., Theobald, N.D., 1996. The effects of school districts spending priorities on length of stay in teaching, Journal of Human Resources 31, 477-512.

Hanushek, E.A., 1986. The economics of schooling: Production and efficiency in public schools, Journal of Economic Literature 24, 1141-77

Hanushek, E.A., Kain, J.F., Rivkin, S.G., 1999. Do higher salaries buy better teachers? NBER Working Paper Series No. 7082.

Holzer, H., Katz, L., Krueger, A.B., 1991. Job queues and wages: New evidence on the minimum wage and interindustry structure, Quarterly Journal of Economics 106, 739-768.

Hoxby, C.M., 1996. How teachers' unions affect education production, Quarterly Journal of Economics 111, 671-718.

Kenny, L.W., Denslow, D.A., 1980. Compensating differentials in teachers' salaries, Journal of Urban Economics 7, 198-207.

Krueger, A.B., 1988. The determinants of queues for federal jobs, Industrial and Labor Relations Review 41, 567-581.

Ladd, H.F., Fiske, E.B., The uneven playing field of school choice: Evidence from New Zealand, Journal of Policy Analysis and Management 20, 43-64.

Levinson, A.M., 1988. Reexamining teacher preferences and compensating wages, Economics of Education Review 7, 357-364.

Monk, D.H., 1994. Subject area preparation of secondary mathematics and science teachers and student achievement, Economics of Education Review 13, 125-45

Murnane, R.J., Olsen, R.J., 1990. The effects of salaries and opportunity costs on length of stay in teaching. Evidence from North Carolina, Journal of Human Resources 25, 106-124.

Neyman, J., Scott, E. L., 1948. Consistent estimation from partially consistent observations, Econometrica 16, 1-32.

Romer, T., Rosenthal, H., Munley, V., 1992. Economic incentives and political institutions: Spending and voting in school budget referenda, Journal of Public Economics 49, 1-33.

Zabalza, A., 1979. The determinants of teacher supply, Review of Economic Studies 46, 131-147.

Table 1. The relationship between student achievement and teacher certification

Dependent variable, achievement in	Reading		Mathematics		Science	
Log number of students	14.6	16.4	4.85	7.05	7.00	8.40
	(2.36)	(2.59)	(0.84)	(1.20)	(1.14)	(1.34)
Student-teacher ratio	-2.05	-1.96	-1.13	-0.82	-0.64	-0.46
	(0.90)	(0.78)	(0.52)	(0.36)	(0.28)	(0.18)
Q	40.42	-	56.8	-	38.1	-
	(1.34)		(2.22)		(1.40)	
Q=1	-	19.8	-	16.2	-	17.4
		(2.97)		(2.50)		(2.61)
R^2	0.06	0.09	0.06	0.05	0.03	0.05
Number of schools	136	136	136	136	135	135
Standard deviation of depended variable	39.7		36.0		38.5	
Correlation coefficient between dependent variable and Q	0.19 [0.024]		0.16 [0.050]		0.28 [0.001]	

Note. All calculations are weighted by the number of students participating at each school in each test. The models in the first part of the table are estimated by OLS. Absolute standard errors corrected for White heteroscedasticity in parentheses and p-values in brackets.

Table 2. Minority students and immigrants from former Yugoslavia

		Share of the minority students with mother language		
	Share of minority students	Bosnian	Albanian	Bosnian + Albanian
1992	0.026	0.001	0.014	0.014
1993	0.029	0.001	0.016	0.017
1994	0.033	0.002	0.028	0.030
1995	0.035	0.107	0.053	0.160
1996	0.036	0.113	0.058	0.171
1997	0.038	0.102	0.060	0.161
1998	0.040	0.097	0.056	0.153
1999	0.044	0.081	0.074	0.155

Table 3. Descriptive statistics

Sample	All		Q < 1		Q = 1	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Log of teacher supply per student LS/P	-2.35	0.33	-2.40	0.31	-2.30	0.34
Log of teacher demand per student LD/P	-2.29	0.34	-2.28	0.34	-2.30	0.34
Log of teacher quality Q	-0.064	0.131	-0.120	0.159	0	-
Minority share	0.038	0.078	0.047	0.089	0.028	0.062
Special needs share	0.066	0.052	0.069	0.049	0.063	0.056
Log teacher education hours per student	4.56	0.33	4.58	0.33	4.55	0.33
Log minimum teacher education hours per student	4.05	0.38	4.03	0.37	4.06	0.38
Log number of students	4.67	1.07	4.79	1.04	4.53	1.09
Change in the log number of students	0.036	0.145	0.040	0.141	0.031	0.153
Number of students below 20	0.084	-	0.071	-	0.100	-
Number of students between 20 and 60	0.194	-	0.166	-	0.227	-
The school has a library	0.266	-	0.287	-	0.242	-
Only students at the primary educational level, with separate classes at each grade	0.360	-	0.369	-	0.349	-
Only students at the lower secondary educational level, with separate classes at each grade	0.148	-	0.156	-	0.139	-
Students both at the primary and lower secondary educational level, with separate classes for each grade at the lower secondary educational level	0.122	-	0.146	-	0.095	-
Neither of the above mentioned school types	0.370	-	0.329	-	0.416	-
School year 1995–96	0.200	-	0.172	-	0.234	-
School year 1996–97	0.200	-	0.168	-	0.238	-
School year 1997–98	0.199	-	0.210	-	0.187	-
School year 1998–99	0.200	-	0.229	-	0.167	-
School year 1999–2000	0.200	-	0.222	-	0.175	-
Observations	15,842		8,481		7,361	

Table 4. The teacher supply function. Dependent variable is the log of the supply of certified teachers per student LS/P

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Data level	School level						Local government level[b]
Sample	All	Q < 1	Q < 1	Q < 1	Q < 1	Q < 1	Q < 0.98
Minority share	-0.174 (0.041)*	-0.168 (0.043)*	-0.126 (0.076)	-0.221 (0.066)*	-0.302 (0.064)*	-0.166 (0.029)*	-0.060 (0.106)
Special needs share	0.141 (0.077)	0.201 (0.077)*	0.087 (0.072)	0.198 (0.077)*	0.102 (0.087)	-	0.063 (0.099)
Special needs share –Mild	-	-	-	-	-	0.212 (0.071)*	-
Special needs share - Moderate	-	-	-	-	-	0.177 (0.073)*	-
Special needs share – Major	-	-	-	-	-	0.277 (0.105)*	-
Log teacher education hours per student	0.750 (0.021)*	0.869 (0.022)*	0.646 (0.023)*	0.876 (0.022)*	0.969 (0.037)*	0.870 (0.013)*	0.777 (0.032)*
Local government – year specific effects	Yes	Yes	Yes	Yes	Yes	Yes	No
School specific effects	No	No	Yes	No	No	No	No
Estimation method	Tobit	OLS	OLS	2SLS	2SLS	OLS	OLS
Endogenous variable	-	-	-	Minority share	Minority share, Log teacher education hours per student	-	-
Instruments[a]	-	-	-	SBA, NBA	UM, SBA, NBA	-	-
OIR, p-value	-	-	-	0.210	0.221	-	-
Observations	15 841	8 481	8 481	8 481	8 481	8 476	1 515

Note: Standard errors (in parentheses) are corrected to account for within-school clustering of errors, and * denotes significance at five percent level. All models have the same specification except as indicated. In addition to the reported variables, the models include the log of the number of students, dummy variables for schools with less than 20 students and less than 60 students, the change in the log of the number of students, a dummy variable for whether the school has a library, and dummy variables for whether all of the students at the school are at the primary educational level with separate classes for each grade, whether all of the students at the school are at the lower secondary educational level with separate classes for each grade, or whether there are students at both the primary and lower secondary educational level with separate classes for each grade at the upper secondary education level.

[a] SBA is the *share* of students with mother language either Bosnian or Albanian, NBA is the *number* of students with mother language either Bosnian or Albanian, and UM is the log of minimum teacher education hours per student.

[b] The log of population size, the share of the population in rural areas, county specific effects, and time specific effects are included in the model.

Table 5. The teacher demand function. Dependent variable is the log of the teacher demand per student LD/P

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	All	Q = 1	All	All	All	All
Minority share	0.873 (0.068)*	0.664 (0.070)*	0.629 (0.042)*	0.293 (0.034)*	0.811 (0.065)*	0.649 (0.041)*
Special needs share	1.091 (0.086)*	0.932 (0.091)*	1.005 (0.069)*	0.607 (0.026)*	0.994 (0.068)*	-
Special needs share – Mild	-	-	-	-	-	0.441 (0.048)*
Special needs share – Moderate	-	-	-	-	-	0.904 (0.059)*
Special needs share – Major	-	-	-	-	-	1.673 (0.231)*
Log minimum teacher education hours per student	0.712 (0.020)*	0.689 (0.023)*	0.653 (0.014)*	0.439 (0.10)*	0.654 (0.014)*	0.657 (0.15)*
Local government – year specific effects	Yes	Yes	Yes	Yes	Yes	Yes
School specific effects	No	No	No	Yes	No	No
Estimation method	Tobit	OLS	OLS	OLS	2SLS	OLS
Endogenous variable	-	-	-	-	Minority share	-
Instruments[a]	-	-	-	-	SBA, NBA	-
OIR, p-value	-	-	-	-	0.034	-
Observations	15 842	7 361	15 842	15 842	15 842	15 835

Note: Standard errors (in parentheses) are corrected to account for within-school clustering of errors, and * denotes significance at five percent level. All models have the same specification except as indicated. In addition to the reported variables, the models include the log of the number of students, dummy variables for schools with less than 20 students and less than 60 students, the change in the log of the number of students, a dummy variable for whether the school has a library, and dummy variables for whether all of the students at the school are at the primary educational level with separate classes for each grade, whether all of the students at the school are at the lower secondary educational level with separate classes for each grade, or whether there are students at both the primary and lower secondary educational level with separate classes for each grade at the upper secondary education level.

[a] SBA is the *share* of students with mother language either Bosnian or Albanian and NBA is the *number* of students with mother language either Bosnian or Albanian.

Table 6. The teacher quality function. Dependent variable is the log of teacher quality Q

	(1)	(2)	(3)	(4)	(5)
Sample	All	All	All	All	All
Minority share	-0.174 (0.029)*	-0.124 (0.038)*	-0.264 (0.041)*	-0.171 (0.029)*	-0.285 (0.034)*
Special needs share	-0.038 (0.043)	-0.110 (0.029)*	-0.032 (0.043)	-	-0.102 (0.061)
Special needs share – Mild	-	-	-	0.003 (0.058)	-
Special needs share – Moderate	-	-	-	-0.077 (0.065)	-
Special needs share – Major	-	-	-	0.015 (0.066)	-
Log minimum teacher education hours per student	-0.042 (0.013)*	-0.024 (0.011)*	-0.043 (0.013)*	-0.043 (0.013)*	-0.086 (0.018)*
Local government – year specific effects	Yes	Yes	Yes	Yes	Yes
School specific effects	No	Yes	No	No	No
Estimation method	OLS	OLS	2SLS	OLS	Tobit
Endogenous variable	-	-	Minority share	-	-
Instruments[a]	-	-	SBA, NBA	-	-
OIR, p-value	-	-	0.768	-	-
Observations	15 842	15 842	15 842	15 835	15 8542

Note: Standard errors (in parentheses) are corrected to account for within-school clustering of errors, and * denotes significance at five percent level. All models have the same specification except as indicated. In addition to the reported variables, the models include the log of the number of students, dummy variables for schools with less than 20 students and less than 60 students, the change in the log of the number of students, a dummy variable for whether the school has a library, and dummy variables for whether all of the students at the school are at the primary educational level with separate classes for each grade, whether all of the students at the school are at the lower secondary educational level with separate classes for each grade, or whether there are students at both the primary and lower secondary educational level with separate classes for each grade at the upper secondary education level.

[a] SBA is the *share* of students with mother language either Bosnian or Albanian and NBA is the *number* of students with mother language either Bosnian or Albanian.

Appendix Table A1. Full models

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Log of teacher supply per student LS/P		Log of teacher demand per student LD/P		Log of teacher quality Q	
Specification	Column (1) in Table 4	Column (2) in Table 4	Column (2) in Table 5	Column (3) in Table 5	Column (1) in Table 6	Column (5) in Table 6
Minority share	-0.174 (0.041)*	-0.168 (0.043)*	0.664 (0.070)*	0.629 (0.042)*	-0.174 (0.029)*	-0.285 (0.034)*
Special needs share	0.141 (0.077)	0.201 (0.077)*	0.932 (0.091)*	1.005 (0.069)*	-0.038 (0.043)	-0.102 (0.061)
Log teacher education hours per student	0.750 (0.021)*	0.869 (0.022)*	-	-	-	-
Log minimum teacher education hours per student	-	-	0.689 (0.023)*	0.653 (0.014)*	-0.042 (0.013)*	-0.086 (0.018)*
Log number of students	-0.054 (0.007)*	-0.019 (0.007)*	-0.022 (0.008)*	-0.031 (0.005)*	0.004 (0.004)	-0.021 (0.006)*
Change in the log number of students	-0.107 (0.017)*	-0.075 (0.019)*	-0.042 (0.025)	-0.049 (0.015)*	-0.042 (0.010)*	-0.067 (0.015)*
Number of students below 20	-0.084 (0.020)*	-0.165 (0.023)*	0.036 (0.015)*	0.039 (0.012)*	-0.071 (0.012)*	-0.103 (0.017)*
Number of students between 20 and 60	-0.021 (0.010)*	-0.042 (0.011)*	-0.009 (0.008)	0.004 (0.007)	-0.016 (0.005)*	-0.023 (0.009)*
The school has a library	-0.0042 (0.005)	0.000 (0.005	0.006 (0.005)	0.014 (0.003)*	-0.001 (0.002)	-0.007 (0.004)
Only students at the primary educational level, with separate classes at each grade	-	-	-	-	-	-
Only students at the lower secondary educational level, with separate classes at each grade	0.164 (0.006)*	0.150 (0.005)*	0.213 (0.006)*	0.208 (0.004)*	0.010 (0.003)*	0.015 (0.005)*
Students both at the primary and lower secondary educational level, with separate classes for each grade at the lower secondary educational level	0.083 (0.008)*	0.069 (0.007)*	0.102 (0.009)*	0.098 (0.006)*	0.007 (0.004)	0.009 (0.007)
Neither of the above mentioned school types	0.018 (0.010)	0.026 (0.009)*	0.025 (0.010)*	0.025 (0.007)*	0.004 (0.005)	0.002 (0.009)
Local government – year specific effects	Yes	Yes	Yes	Yes	Yes	Yes
School specific effects	No	No	No	No	No	No
Estimation method	Tobit	OLS	OLS	OLS	OLS	Tobit
Observations	15,842	8,481	7,361	15,842	15 842	15 842

Note: Standard errors (in parentheses) are corrected to account for within-school clustering of errors, and * denotes significance at five percent level.

Table A2. First stage regressions. Dependent variable is specified in the second row

	(1)	(2)	(3)	(4)
Dependent variable	Minority share	Minority share	Log teacher education hours per student	Minority share
Specification	Column (4) in Table 3	Column (5) in Table 3	Column (5) in Table 3	Column (5) in Table 4 and column (3) in Table 5
Special needs share	-0.032	0.063	1.067	0.047
	(0.021)	(0.021)*	(0.137)*	(0.013)*
Log teacher education hours per student	0.087	-	-	-
	(0.011)*			
Log minimum teacher education hours per student (UM)	-	-0.011	0.615	-0.008
		(0.007)	(0.019)*	(0.007)
Share of the students with mother language either Bosnian or Albanian (SBA)	0.804	0.879	1.114	1.155
	(0.257)*	(0.278)*	(0.409)*	(0.259)*
Number of the students with mother language either Bosnian or Albanian (NBA)	0.0067	0.0072	0.0043	0.0058
	(0.0016)*	(0.0016)*	(0.0014)*	(0.0013)*
Local government – year specific effects	Yes	Yes	Yes	Yes
F-test for the instruments	68.4	48.2	394.1	97.2
Observations	8 481	8 481	8 481	15 842

Note: Standard errors (in parentheses) are corrected to account for within-school clustering of errors, and * denotes significance at five percent level. All models have the same specification except as indicated. In addition to the reported variables, the models include the log of the number of students, dummy variables for schools with less than 20 students and less than 60 students, the change in the log of the number of students, a dummy variable for whether the school has a library, and dummy variables for whether all of the students at the school are at the primary educational level with separate classes for each grade, whether all of the students at the school are at the lower secondary educational level with separate classes for each grade, or whether there are students at both the primary and lower secondary educational level with separate classes for each grade at the upper secondary education level.

Figure 1. The teacher labour market and the identification strategy

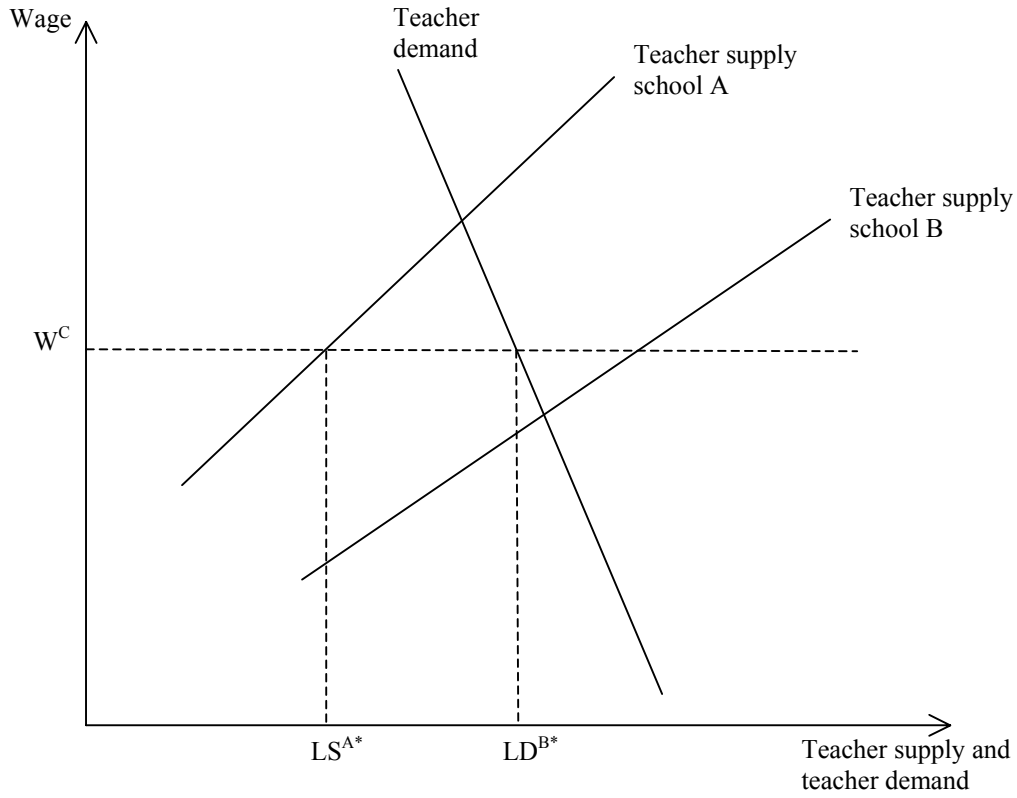

Figure 2. Distribution of teacher quality Q, Q=1 excluded

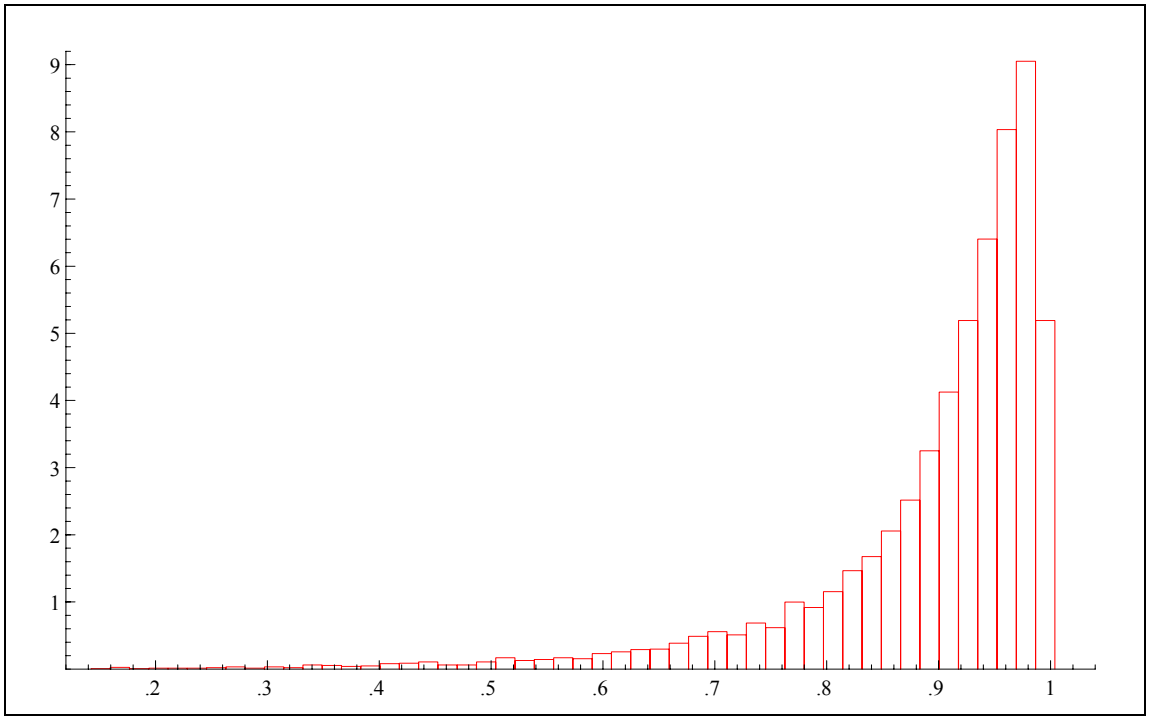

Figure 3. Distribution of the number of students at school

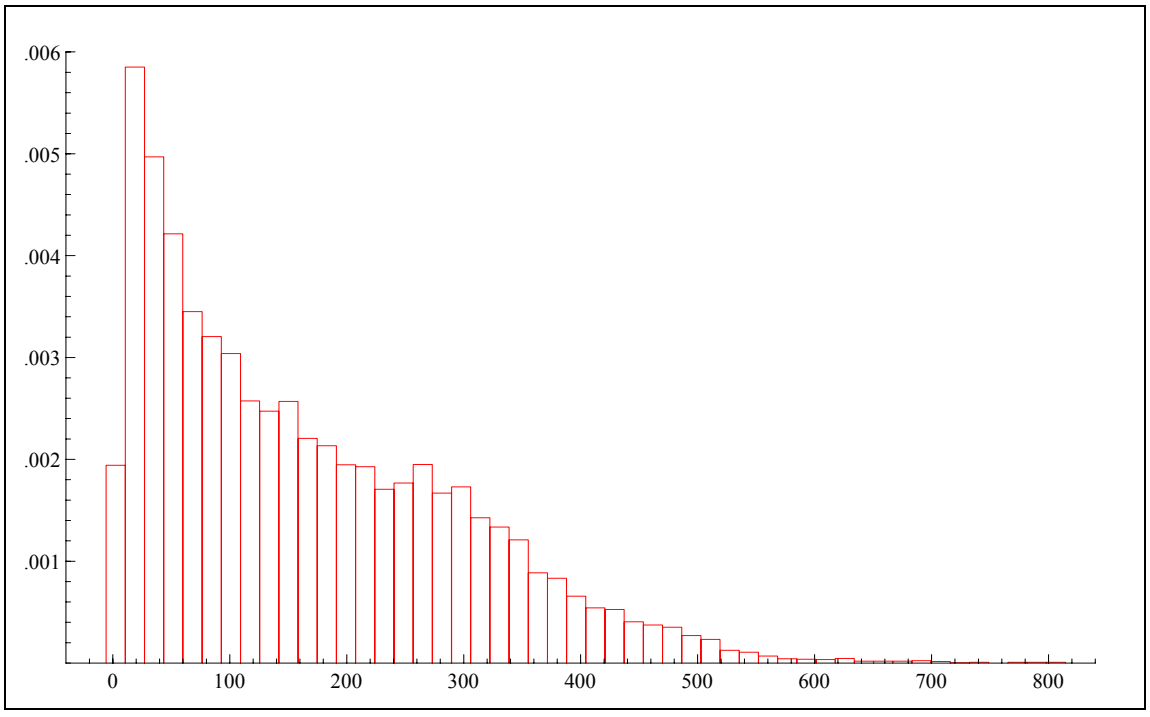

Figure 4. Distribution of the minority share, schools without minority students are excluded

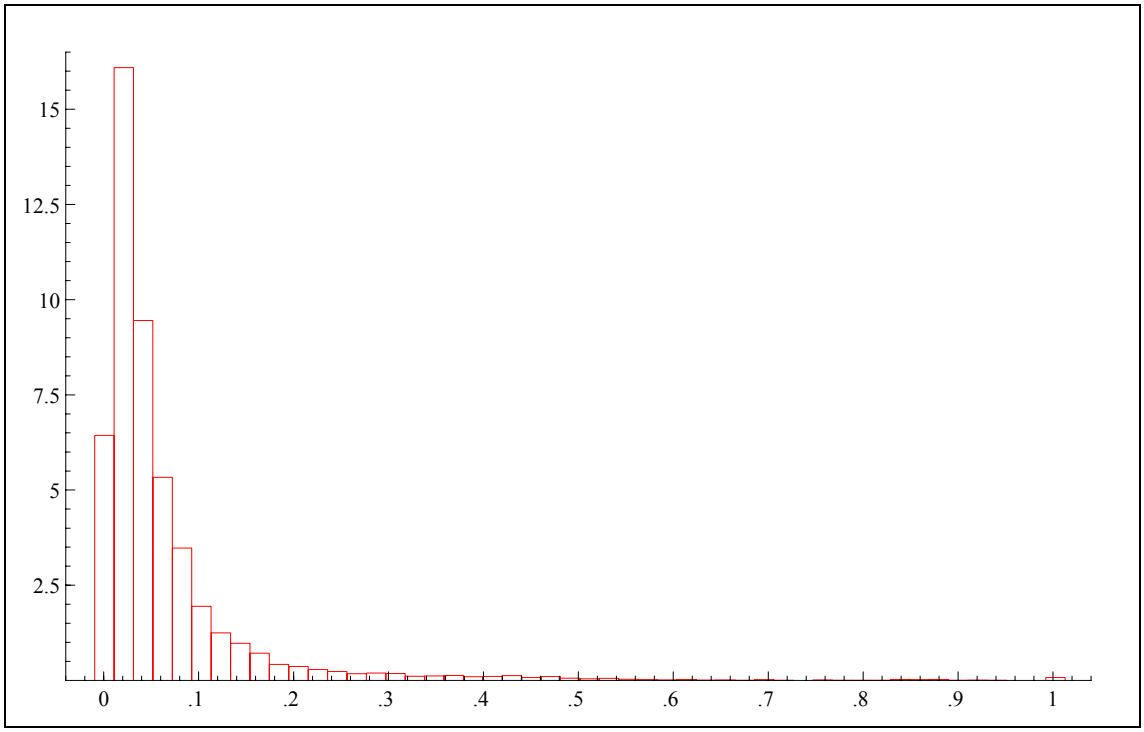

Figure 5. Distribution of the share of students with special needs