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journal homepage: www.elsevier.com/locate/labecoTeacher shortages and the business cycle[☆]Torberg Falch, Kåre Johansen, Bjarne Strøm^{*}

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ABSTRACT

The ability of the public sector to recruit skilled workers is important for the quality of public sector services. Centralized and rigid pay systems in the public sector might reduce labour supply and lead to shortages of qualified personnel in areas and periods with strong outside labour markets. This paper shows that teacher shortages measured by the share of teachers without approved education are strongly procyclical in Norway. Using a large panel of Norwegian local governments for 1981–2002 and exploiting the rigid wage system, we find a sizeable negative relationship between teacher shortages and the regional unemployment rate.

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1. Introduction

There is a growing concern that the quality of public sector services is falling because of problems in the recruitment of high-quality workers. The ability of the public sector to master future challenges in service production depends on the talent, motivation, training, and organization of the people who do the work for the governments. The importance of labour quality is emphasized for several public sector services in numerous papers.¹ Indeed, Nickell and Quintini (2002) provide evidence that the quality of public sector workers in the UK has decreased in the recent 30 years at the same time as relative wages have fallen. Corcoran et al. (2004), Lakdawalla (2006), and Bacolod (2007) present evidence from the US of both falling teacher relative wages and reduced relative ability of teachers.²

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¹ See for example Borjas (2003) for the public sector in general, Temin (2002) and Hanushek (2006) for education, Krueger (1988) for federal jobs, Carrell (2007) for military services, and Hall et al. (2008) for hospitals.

² The hypothesis of Stoddard (2003) and Lakdawalla (2006) is that US schools over the latest decades have substituted quality by quantity, and they find that such substitution can explain the combination of rising teacher–student ratios and falling teacher relative wages. Baumol (1967) argues that technical progress in many public services, with education as a prominent example, is lower than in the rest of the economy, which increases the relative price of skills in the long run.

The present paper studies the relationship between skill composition in the public sector and the state of the labour market. Public sector labour markets are characterized by centralized decisions and strong trade unions in many developed countries (Bell et al., 2007), and centralized systems are typically regarded as rigid in the sense that wage variation across occupations and regions is very limited. The quality of public sector workers might therefore vary cyclically, and serious local labour market imbalances with excess demand in some areas and excess supply in other areas might occur as labour market opportunities outside the public sector varies.

Little systematic evidence exists on the extent of cyclical and regional imbalances in public sector labour markets. Studies mainly from the US and the UK provide evidence that outside opportunities affect supply decisions in different occupations. For example, Carrell (2007) finds that strong external local labour markets increase turnover within the United States Air Force.³ Hall et al. (2008) find that hospital production decreases as outside labour market opportunities improves within the centralized wage system of medical staff in English acute hospitals.

The limited evidence on determinants of worker quality in the public sector compared to pure employment evidence is related to a measurement problem. How should worker quality be quantified? The ideal solution would be to measure the productivity of worker's with different observable characteristics, but this is typically very difficult due to the problems of measuring production in public institutions. An alternative to the direct approach is to study the relationship between availability of workers with certain characteristics and the conditions

³ For the effect of alternative wages for the teacher labor market, see for example Dolton and van der Klaauw (1995) and Chevalier et al. (2007). For nurses, Elliott et al. (2007) find similar effects. However, Kim (1999) finds that relative pay has little or no effect on the turnover within the State of California's Civil Service.

in the labour market. This is the approach followed in this paper. We exploit institutional characteristics in Norwegian compulsory education to establish a rigorous measure of teacher shortages. Completely centralized wage setting and a strict national appointment rule are essential in this regard. According to the school law, schools can only employ persons without a teaching certification if no certified teachers apply to a vacant teacher position, and non-certified teachers can only be employed for up to one school year. Thus, the only possible response to shortages of certified teachers is to hire non-certified teachers on short-term contracts. Teacher shortages measured as the share of non-certified teachers thus reflect the state of the teacher labour market in a particular year and geographical area.⁴ If this measure of teacher shortages increases, it reflects low interest for vacant positions, lack of options in the schools hiring processes, and thus low teacher quality.

In this paper we provide new evidence on the effect of outside labour market conditions on teacher shortages. We mainly rely on a long regional panel data set from 1981–2002 to analyze the cyclical pattern of teacher shortages, but we also provide some time-series evidence for the period 1973–2002. One problematic feature of time-series analyses is that teacher wages and teacher shortages are at least in part jointly determined. In a panel data analysis, fixed year effects account effectively for variation in teacher wages in a centralized wage setting system. Further, by including regional fixed effects we control for invariant differences in outside opportunities and general attractiveness across local labour markets. Conditional on other covariates, the temporal variation in regional unemployment can be used to estimate the business cycle impact on teacher shortages.

Some papers have analyzed similar measures of public sector work force quality. Krueger (1988) analyzes time-series data for the US federal sector and finds that the number of applicants per vacant federal job is positively related to both the relative wage and the general unemployment rate. Based on NLSY data for females, Bacolod (2007) finds that the lower teachers are paid relative to professionals, the less likely are high-quality educated women to choose a teacher career.

A related literature to the present study examines teachers' decisions on whether to leave or stay in teaching. The findings regarding the effects of relative teacher wages are mixed, see for example Hanushek et al. (2004) and Scafidi et al. (2007).⁵ One particular concern with this literature is that the school district wage level may respond to teacher behaviour. Evidence from the UK suggests that the decline in relative teacher wages has reduced the share of graduates choosing to teach, see Dolton and van der Klaauw (1995) and Chevalier et al. (2007). Thus, the evidence indicates that teacher wages are more important for the decision to become a teacher than for the decision to exit teaching, and that absence of geographical pay flexibility may lead to inefficiencies in the teacher labour market. The evidence on the effects of unemployment is scarce, but Falch and Strøm (2005) find that regional unemployment decreases the probability to leave teaching, in particular for women 30–50 years of age. We deal with gender specific labour market conditions in our panel data analysis.⁶

The paper is organized as follows. Section 2 presents the institutional set-up and a simple theoretical framework to understand the working of the teacher labour market. Section 3 shows time-series evidence on the relationship between teacher shortages relative teacher wages and total unemployment. Section 4 presents panel data evidence from estimating the relationship between local teacher shortages and local unemployment. Section 5 concludes.

2. Institutions and theoretical framework

2.1. Institutions

Similar to many other European countries, teacher pay setting in Norway is highly centralized with bargaining at the national level. In the period covered in the present paper, teacher wages and workload were completely determined in national bargains.⁷ In a given year, the wage for an individual teacher was solely determined by the amount of formal education and teaching experience. The national contracts effectively prevented schools and local governments to use wage and workload policy to attract teachers.

The school law requires that only persons with a teacher certificate can be employed in permanent positions. Non-certified persons can be appointed only in cases where no certified teachers are willing to accept a vacant teacher position. According to the national contracts, representatives of the teacher union must be informed prior to every hiring decision and in this way the union is able to closely monitor that the schools and local governments operate in accordance with the rule, which have been one of the cornerstones in the teacher union policy. By this legislation, the number of non-certified teachers relative to total number of teachers is a measure of teacher shortages. Variations in this measure are indeed followed with large attention by commentators and politicians.

The degree of turnover in Norwegian schools clearly makes teacher shortages vulnerable to shocks in the private sector labour market. Falch and Strøm (2005) show that the quit rate of teachers below 60 years of age who are employed in permanent positions is about 10% in Norway in the 1990s. Separations are higher, at about 17%, because of retirement decisions and because some teachers are employed in temporary positions. The recruitment rate is slightly higher than the separation rate since teacher employment increased during the empirical period.⁸ This teacher turnover rate is comparable to the US and UK.

Public primary and lower secondary education in Norway (first through tenth grade) are comprehensive in the sense that no tracking takes place. An important element in the education policy in Norway has been to integrate children with different backgrounds and ability. The school enrolment date is in the year the child turns six and is basically not subject to parental choice, and students almost never retain a grade or get promoted faster than the normal rule. Thus, a grade consists of children born in the same calendar year, and the pupils have to a large extent the same classmates during the years of compulsory schooling.⁹

Primary and lower secondary education are the responsibility of the local governments.¹⁰ The local governments are multipurpose

⁷ A very limited amount of local flexibility in wage setting was introduced in 2001, and the formal possibilities of local wage bargaining for teachers have gradually increased in recent years. Thus, in the empirical analysis we restrict the attention to the years up to the school year 2002–03.

⁸ A more detailed investigation of the separations following the specific school year 1998–99 shows that there were 10.5% separations for non-teaching alternatives and 8.4% separations for another teaching job. Consider those who left for the non-teaching alternatives. Around half of them held a permanent teacher position, while the other half was appointed temporarily. 13.3% were above 60 years of age and likely to represent retirements. Another 13.4% returned to a teacher position in the same school within two years and contains to a large extent those on maternity leaves. 12.6% returned to another school within two years and represents mobility within the educational sector. Finally, 57.8% of those who left for non-teaching alternatives were below 60 years in 1998 and did not return to the educational sector within the sample period.

⁹ There are typically separate primary and lower secondary schools. The lower secondary schools tend to be larger than the primary schools because they have a larger catchment area. About 15% of the schools are so-called combined schools with first to tenth grade. In the data we are not able to distinguish between school types for the first years.

¹⁰ Private schools are mostly religious schools and do not provide an alternative to public schools. The share of students in private schools was 1.2% in the fall 1992 and 1.9 in the fall 2002.

⁴ Bonesrønning et al. (2005) use the same shortages measure to analyze the relationship between teacher sorting and student composition using school level data.

⁵ Neither of these studies includes the unemployment rate as a measure of outside opportunities.

⁶ Flyer and Rosen (1997) argue that the growing costs of elementary and secondary education can be related to the rising value of women's time.

institutions that provide other services in addition to education. Student enrolment together with a maximum class size rule that operated within the period of the empirical analysis is a key determinant of teacher demand.¹¹ In addition the local governments are, according to the school act, required to provide supplemental instruction to students with special needs and students with a bad command in the Norwegian language. Conditional on these requirements, the local governments are free to determine the number of teachers, and most local governments have more teachers than required by the national regulations. An important difference between local governments in Norway and most other countries is that the local politicians have very little discretion in the determination of the local budget. The fiscal system is highly centralized with centrally determined income tax rate, only a minor property tax, and considerable income redistribution between local governments through the central government grant system.

2.2. Teacher shortages and teacher quality

A tricky question is how to measure the relationship between teacher quality and the state of the labour market. Our approach is to study to what extent the availability of teachers with certain characteristics varies with conditions in the labour market. We use teacher shortages as measured by the share of non-certified teachers as our quality indicator. Teacher certification in Norway requires either a teacher college degree or a university degree with a certain amount of course work in pedagogy. With one of these types of education, the teacher is certified to teach from first to tenth grade, throughout the entire compulsory schooling. How well does variation in teacher shortages in general reflect variation in teacher quality? A position as non-certified teacher in the Norwegian institutional setting is not attractive for either the teacher or the school. For the schools, appointments of non-certified teachers reflect that they are unattractive from the teachers' point of view. Non-certified teachers can only be employed on short-term contracts of maximum one school year and only if no individuals with a teaching certificate are interested in the position, and they must therefore expect to look for another job the next school year. Thus, it is reasonable to expect non-certified teachers to have low qualifications. Indeed, non-certified teachers in Norway are typically young with lower experience and less education than certified teachers. For the school year 1997–98, 5.5% of the teachers (and 3% of the man-years) were non-certified. Almost 60% of them had no more than high school education. 40% of the non-certified teachers were below 30 years of age compared to 13% among certified teachers, and 48 and 8%, respectively, had less than three years of experience.¹²

Another way to illustrate the very different composition of certified and non-certified teachers is to compare the future careers of novice teachers. In the school year 1997–98, 44% of the teachers without experience were non-certified. However, while 65% of the novice certified teachers were in the public school system the next school year, that was the case for only 34% of the novice non-certified teachers. Ideally, we would like to have direct information on the type of alternative jobs non-certified teachers can take. While such information is not available, some limited evidence based on labour histories for employees in the education sector exists. Using a representative sample of individuals working in the educational sector in 1995, Schöne (1999) finds that during the following year about 2% leave for jobs in private services, another 2% for jobs in public administration, and about 1% leave for other sectors of the economy.

¹¹ The maximum number of students in a class was 28 in primary school and 30 in lower secondary school in the empirical period. Leuven et al. (2008) show that the rule is a very good predictor of actual class size in Norway.

¹² These numbers are similar for the whole period for which we have individual data, the school years 1992–93 to 2002–03.

In addition, some teachers leave for administrative jobs within the educational sector. It seems reasonable to suggest that lack of better job opportunities is one of the main reasons why non-certified teachers take teacher jobs. Nevertheless, some of them get a certification later on and may therefore have long-term plans with their initial teacher position. Among the novice non-certified teachers in 1997–98, 15 and 23% were certified and worked in a public school in 1998 and 2002, respectively.¹³

Overall, despite non-certified teachers being a heterogeneous group, their average characteristics seem to work in the direction of a negative effect on student performance. Regarding educational level, the US evidence may suggest that formal teacher education is a poor measure of teacher quality, see for example Hanushek (2006). The bulk of this evidence, however, comes from studies comparing master and bachelor degrees, and not from analysis of the effect of certification arrangements. Some recent analyses indicate that teacher credentials have an important impact on student achievement, see for example Clotfelter et al. (2007, 2009), Goldhaber (2007), and Goldhaber and Anthony (2007). Although a proportion of the non-certified teachers in Norway end up as certified, Bonesrønning et al. (2005) report a negative effect of non-certified teachers on student achievement using the PISA2000 sample for Norway.¹⁴ One important reason may be that non-certified teachers tend to be inexperienced. Evidence clearly indicates that novice teachers are less productive than experienced teachers, see for example Hanushek (2006). Moreover, Bressoux et al. (2009) find that in France trained novice teachers are substantially more productive in terms of student test scores than untrained novice teachers.

2.3. Theoretical framework

We start with a simple aggregate model of the teacher labour market where teacher shortages and teacher relative wages are jointly determined. We use this model to explain our empirical strategies to infer the link between teacher shortages and the unemployment rate. To fix ideas, suppose that national teacher relative wages and teacher shortages are determined by the following equations:

$$\frac{W}{\bar{W}} = a_1 Q + a_2 U + a_3 X \quad (1)$$

$$Q = b_1 \frac{W}{\bar{W}} + b_2 U + b_3 D + b_4 S \quad (2)$$

where Q is teacher shortages, W is the teacher wage, \bar{W} is the alternative wage, U is the unemployment rate, X is a vector of other variables that may affect teacher relative wages, and D and S are teacher demand and supply shifters, respectively, affecting teacher shortages. Eq. (1) is the wage setting curve, where we assume that a_1 is positive, i.e. high teacher shortages increase the teacher relative wage. This assumption is consistent with bargaining theories of wage determination since teacher wage claims are likely to increase in times with teacher shortages where the risk of being unemployed is low.¹⁵ The more market

¹³ Out of the novice teachers in 1997–98, 47 and 25% of the certified and non-certified teachers, respectively, are employed as teachers in 2002–03. Regarding the latter, only 2% are still non-certified.

¹⁴ The evidence reported in Bonesrønning et al. (2005) is based on data for Norway from the Program for International Student Assessment (PISA) undertaken by OECD and uses data for the year 2000, which is relevant for the period covered in the present paper. The simple correlation between the share of certified teachers and student achievement in mathematics, science and reading was 0.19, 0.16 and 0.28, respectively, and significant at the 5% level. The significantly positive association between student achievement and share of teachers certified also holds when conditioning on the number of students and the student–teacher ratio.

¹⁵ Previous studies have typically estimated simple market adjustment models where the change in relative teacher wages is regressed against a measure of lagged excess demand for teachers, see Zabalza (1979) and the references in Dolton (2006). From a bargaining model perspective, it is more natural to assume that the bargained wage level depends on the current level of excess demand for teachers as in Eq. (1).

oriented the teacher wage setting is, the higher is the elasticity of relative teacher wages with respect to shortage.

Eq. (2) assumes that teacher shortages are decreasing in both relative teacher wages and the unemployment rate, i.e. b_1 and b_2 are both negative. Higher relative teacher wages increase supply of certified teachers while the demand for teachers decreases as teachers become more expensive to employ. Higher unemployment increases teacher supply since, for given relative wage, the probability to get jobs outside education decreases and thus expected payoff as a teacher relative to alternative employment increases.

Fig. 1 gives a graphical representation of the model where the WW -curve represents Eq. (1) and the QQ curve represents Eq. (2). The figure illustrates how changes in the unemployment rate may affect wages and teacher shortages at the national level in this model. Higher unemployment increases the supply of teachers, indicated by the leftward shift in the QQ curve from QQ^0 to QQ^1 . The effect of unemployment on teacher relative wages depends on whether teacher wages or alternative wages are most responsive with respect to unemployment fluctuations. Fig. 1 assumes that teacher wages are least responsive ($a_2 > 0$), shifting the WW -curve upwards from WW^0 to WW^1 . The reduced form effect of higher unemployment is decreased teacher shortages, while the relative wage effect in general is ambiguous.

An important empirical issue is to separate the direct impact of unemployment on Q from the effect of unemployment on relative wages. This is the fundamental problem of identifying the teacher shortages Eq. (2). In principle one could estimate (2) by using aggregate time-series data provided the existence of time-series variables that can credibly contribute to the identification of the QQ curve. Some time-series evidence is presented below, but our preferred empirical strategy is to rely on regional panel data to estimate the relationship between local government teacher shortages and regional unemployment.

The use of panel data enables us to control for macroeconomic effects and all permanent regional specific variables by using fixed year and local government effects. In particular, as teacher wages are determined completely at the national level, this strategy implies that we get rid of the teacher wage endogeneity problem by using only regional specific temporal variation in the unemployment rate and other variables to explain the temporal variation in municipal specific teacher shortages. While effectively removing the teacher wage endogeneity problem, failure to account for local variations in the alternative regional wage and other supply and demand shifters

might still bias the estimated unemployment effects on teacher shortages. In Section 4 we discuss this problem and possible solutions.

3. Time-series evidence

This section presents time-series evidence on the linkage between aggregate teacher shortages in primary and lower secondary education, aggregate unemployment, and relative teacher wages. Teacher wages are measured relative to the wage rate in private services.¹⁶

Fig. 2 shows the development in aggregate teacher shortages, aggregate unemployment rate, and the relative wage during the period 1973–2002. The share of non-certified fulltime teachers varies between 1 and 7% and shows a marked downward sloping trend in the 1970s when unemployment was low and stable.¹⁷ However, both unemployment and teacher shortages started to fluctuate significantly from the early 1980s. In particular, the share of non-certified teachers shows a remarkable procyclical pattern. The relative wage has a downward trend until the end of the 1990s for thereafter to increase slightly. However, the relative teacher wage fluctuates much less than teacher shortages and unemployment.

The cyclical pattern in teacher shortages is confirmed by the upper panel in Fig. 3 which presents cross-plot of shortages against unemployment along with the fitted regression line.¹⁸ The slope of the regression line is -0.52 with a t -statistic of -4.57 ($R^2 = 0.45$). Taken at face value, this means that an increase in the aggregate unemployment rate by one percentage point will reduce the share of non-certified teachers by 0.52 percentage points.¹⁹ On the other hand, the cross-plot of shortages against relative teacher wages in the lower panel in Fig. 3 shows a positive association between these two variables, contrary to the model above. Falch et al. (2008) provide evidence on the linkage between teacher shortages, unemployment and relative teacher wages using a formal time-series model with additional covariates and treating relative wages as an endogenous variable. This evidence confirms that a strong procyclical pattern in teacher shortages exists while the impact of teacher relative wages is insignificant. However, a problem with this approach is the small number of observations and potential omitted variables that may lead to biased estimates. In the next section we use a large regional panel data set that enables us to address some of the problems in the time-series approach and to provide a specific analysis of the possible regional imbalances in the teacher labour market caused by the centralized nature of teacher wage setting.

4. Panel data evidence

4.1. Model specification and data

The empirical counterpart to the teacher shortages Eq. (2) for local governments can be written

$$Q_{it} = b_1 \ln \bar{W}_{jt} + b_2 \ln U_{jt} + b_3 D_{it} + b_4 S_{it} + b_5 t + \eta_i + \delta_t + \varepsilon_{it} \quad (3)$$

Q_{it} is teacher shortages in local government i at time t . The error term has three components; a local government specific term η_i , a year specific term δ_t , and an idiosyncratic term ε_{it} . δ_t accounts for all

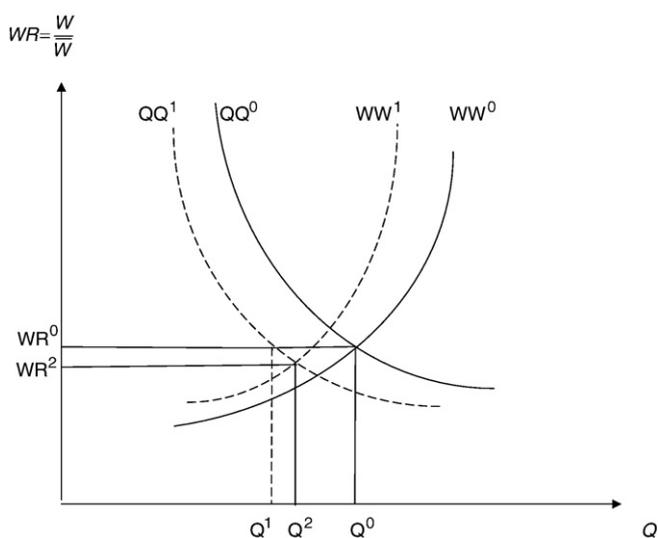


Fig. 1. Teacher relative wage and teacher shortages.

¹⁶ As relative teacher wages we use the average yearly wage for teachers in primary and secondary education relative to the average yearly wage in the private service sector. Detailed data sources for the variables are provided in Appendix A.

¹⁷ Presumably, the downward trend in the 1970s represents a supply side effect driven by the large expansion of higher education in Norway in the late 1960s and early 1970s.

¹⁸ The outliers in 1973 and 1974 are excluded from the figure.

¹⁹ The relation between teacher shortages and unemployment is even stronger when we use the log of the unemployment rate instead of the untransformed rate. Using the log specification we obtain a slope coefficient of -1.61 with t -statistic of -5.65 and $R^2 = 0.53$.

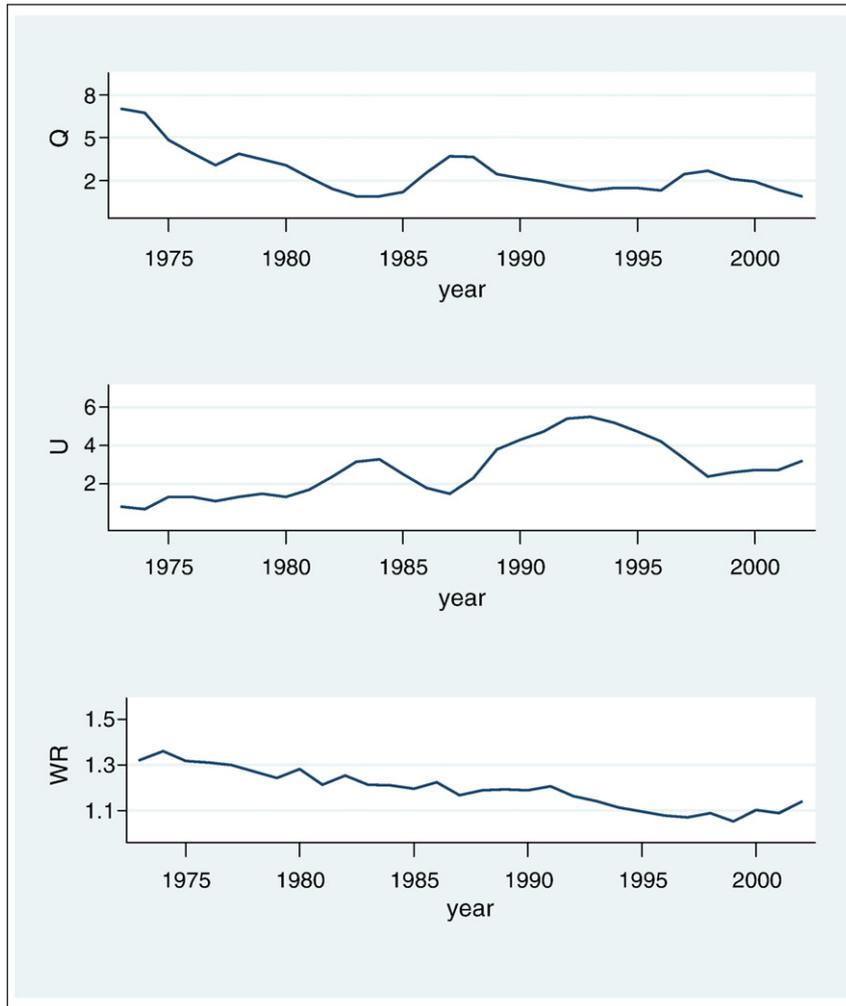


Fig. 2. The share of non-certified fulltime teachers, Q , the unemployment rate, U , and relative teachers' wage, WR , 1973–2002.

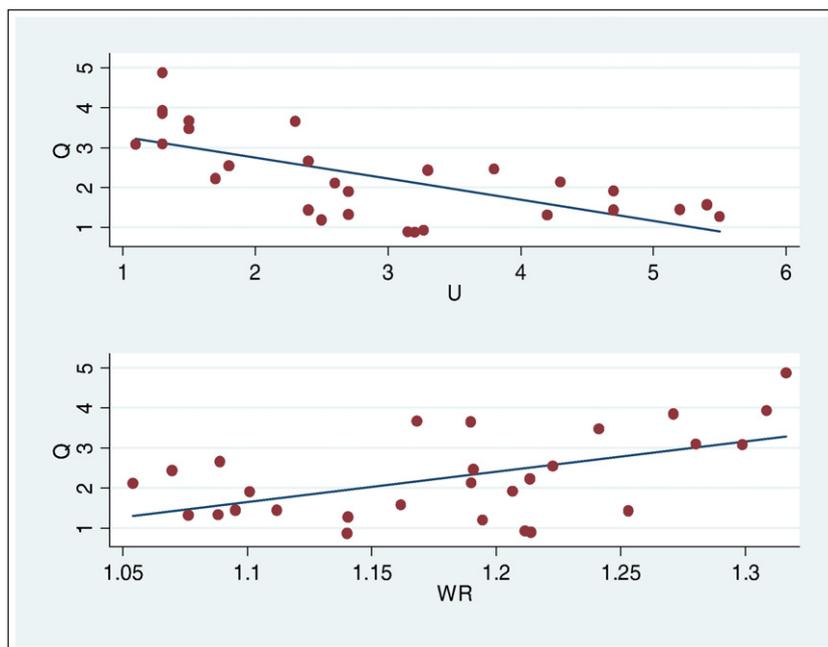


Fig. 3. Scatter plots of the share of non-certified fulltime teachers against unemployment and relative teacher wages with fitted lines, 1975–2002.

variables at the national level affecting teacher shortages, including teacher wages since there is no variation in teacher wages across regions. In addition, δ_t captures macroeconomic fluctuations, changes in national rules on individual teacher workload, and national variations in enrolment.²⁰ η_i captures time-invariant attributes of the local governments. If unemployment tends to be large in areas which appear permanently unattractive for teachers for some geographical or unobserved reason, a model without fixed effects would tend to find a positive spurious association between teacher shortages and unemployment.

A particular concern is the role of migration between regions. The implicit assumption in our theoretical framework was that the unemployment rate affects the probability for teachers to find jobs outside the education sector. Consider a sudden decrease in unemployment in a region. With no regional migration of workers, this translates into an increase in the probability for teachers to find jobs outside education. However, one may argue that lower unemployment leads to migration of people into the region and the composition of the labour force may change in systematic ways if the migration response to unemployment shocks differs between people with different skills. Since such in-migration may increase the competition for jobs and reduce the probability for teachers to get alternative employment, the estimated unemployment effect reflects the combination of these mechanisms. This suggests that the quantitative effects of regional unemployment on teacher shortages may differ between countries to the extent that migration responses differ.

Norwegian evidence suggests that interregional migration responds to unemployment in a statistical significant way, see Carlsen et al. (2006), i.e. lower unemployment in a region increases the net migration rate into the region. A strong relationship between migration and unemployment is also found in Sweden, see Fredriksson (1999) and Westerlund (1997). Further, Eichengreen (1993) finds that regional differences in unemployment have a significant impact on migration within the U.S., while the relationship between within country migration and regional unemployment is much weaker in continental Europe, Norwegian evidence provided in Machin et al. (2008) also suggests that additional education has a significant positive impact on the likelihood of regional mobility. Unfortunately, there is not much empirical evidence on differences in-migration responses to labour market conditions across demographic and educational groups. Carlsen et al. (2006) report somewhat higher migration response to regional unemployment in Norway for the younger than for the older, for men than for women, and for workers with low vs. high level of education. On the other hand, using data on U.S. states, Wozniak (2006) shows that residential choices of college educated workers are more responsive to local labour demand shocks than are those of workers with lower levels of education.

Several of the Norwegian local governments are small with less than 5000 inhabitants, for which the local labour market is likely to go beyond the local government borders. It is not straightforward to define the borders of local labour markets. Based on worker commuting statistics, Statistics Norway has classified 90 different labour market areas consisting on average of 4.8 local governments. We use this classification, and include unemployment U_{jt} and the alternative wage W_{jt} in labour market j at time t in the model. In addition, our baseline model includes regional specific time trends ($b_{5j}t$) to account for smooth regional developments in the variables. Since the local governments vary dramatically in size and the labour market variables are measured at the regional labour market level, all regressions are weighted by the number of inhabitants in each local government by year. The standard errors are clustered at the regional level.

Ideally, we want to include a measure of the wage a teacher would receive if employed in a non-teacher job. It is problematic to create

consistent series of regional wages in Norway for our empirical period 1981–2002. If there is a negative relationship between regional wages and regional unemployment as suggested by the wage curve literature summarized in Blanchflower and Oswald (2005), failure to control for alternative wages in (4) will produce an upward bias in the absolute value of the unemployment effect on teacher shortages. The centralized structure of the wage setting system might itself suggest that this relationship is weak. Empirical estimates of regional wage curves for Norway also indicate that the regional wage elasticity with respect to regional unemployment is relative small. Wulfsberg (1997) and Dyrstad and Johansen (2000) report long run elasticities between -0.02 and -0.035 for Norway based on data from manufacturing industries, compared to an elasticity of -0.1 in most other countries. Falch and Strøm (2006) estimate much smaller and mostly insignificant effects of regional unemployment on local government wages (excluding teachers). To the extent that the relevant alternative labour market for teachers is other local government jobs, this evidence suggests that the bias from excluding measures of alternative wages is quite small. In addition, the time-series evidence above indicates that alternative wages are not important for teacher shortages.

Nevertheless, for the period 1981–1995, we include a measure of the regional average wage in manufacturing industry. Although manufacturing industry may not appear to be the most relevant outside option for teachers, we argue that the regional manufacturing wage is a relevant wage measure. One of the cornerstones in wage setting in Norway has been the Scandinavian inflation model originally formulated by Aukrust (1977). According to this model, traded good sectors which more or less consist of firms in manufacturing industry are wage leaders, while the nontraded sectors (including private services) are wage followers in the national bargains.²¹ Given this strong tradition of manufacturing industries being wage leaders at the macro level, we suggest that these industries are likely to play the same role at the regional level. Moreover, for the period 1991–2002, we include an index of regional house prices.²² If regional private sector wages fluctuate with house prices, including house prices should account for a substantial variation in teachers alternative wages.²³

Student enrolment is clearly the most important determinant of teacher demand. In addition, local government revenue is a demand shifter since education is a normal good. We also include the share of inhabitants above 80 years of age since the largest local government sector in terms of expenditures is care for the elderly. Finally, the model includes the share of foreign citizens in the local government since students with a bad command in Norwegian language have the right to receive additional instruction resources.²⁴

Supply factors vary to a large extent only at the national level. For example, the ministry of education decides the number of study places at the teacher colleges, which are captured by the year specific effects, and graduates are highly mobile. The inclusion of fixed local government effects and regional trends in the empirical model is also motivated by the possible lack of exogenous regional supply variables.

Our dependent variable is the number of teachers without required certification as teachers divided by the total number of teachers

²¹ Evidence confirming the predictions of the Scandinavian model can be found in Johansen and Strøm (1997, 2001), among others.

²² The house price variable is a yearly index constructed from hedonic regressions. Data from registered house transactions are used to regress house price per square meter against house characteristics and regional dummy variables. The coefficients on the regional dummy variables can be interpreted as the average price per square meter for a standardized house in each region and year.

²³ The correlation coefficient between regional manufacturing wages and house prices is 0.6 and highly significant for the period 1991–1995 where data for both variables are available.

²⁴ These variables are the standard variables included in demand studies of Norwegian local governments.

²⁰ For example, student enrolment increased in 1997 due to reduced school entry age from 7 to 6 and extending the number of grades from 9 to 10 in compulsory schooling.

Table 1
Descriptive statistics for the panel data set.

Variable	Mean	Min	Max	Std. dev. total	Std. dev. net of fixed effects	Std. dev. net of fixed effects and regional trends	Observations
Percent non-certified teachers	6.28	0	63.64	6.72	4.34	4.13	9761
Percent non-certified FTE teachers, 1992–2002	3.91	0	50.96	4.57	3.18	3.01	4791
Enrolment per capita	0.13	0.06	0.21	0.02	0.01	0.01	9761
Percent over 80 years of age	4.33	0.93	12.46	1.53	0.45	0.40	9761
Percent foreign citizens	1.85	0	15.00	1.46	0.64	0.60	9761
Local government revenue per capita in 1000 NOK.	26.5	3.1	164.5	15.2	4.0	3.4	9761
Regional unemployment rate (percent)	2.65	0.16	6.89	1.15	0.46	0.39	9761
Male regional unemployment rate (percent)	3.03	0.19	8.72	1.44	0.61	0.51	9761
Female regional unemployment rate (percent)	2.20	0.11	5.52	0.96	0.43	0.35	9761
Regional vacancies (percent), 1986–2002	0.50	0.14	1.80	0.20	0.16	0.08	7871
Wage costs per man-year in manufacturing in 1000 NOK, 1981–1995	177.1	58.6	333.7	55.2	11.4	8.4	6945
House price index, 1991–2002	0.66	0.12	2.45	0.27	0.10	0.05	5556

Notes: Sample period is 1981–2002, unless otherwise specified. Fixed effects include both local government fixed effects and time specific effects. 100 NOK \approx 18 US\$.

employed in primary and lower secondary public schools measured October 1 each year in each local government. An alternative would be to use the number of fulltime equivalent teachers, but this measure is available only for the period 1992–2002.²⁵

In the empirical section below, we perform several robustness checks. We investigate whether the results are stable over time. We include the vacancy rate instead of unemployment rate as our business cycle variable.²⁶ We estimate model versions with lagged teacher shortages as an additional variable to account for possible neglected dynamics, and we estimate a model expanded with quadratic regional trends and geographically differentiated payroll tax rates.

Table 1 presents descriptive statistics. The unweighted average share of non-certified teachers is 6.2% and varies from 0 to 64%. Teacher shortages are absent in 20% of the observations. This suggests that a nonlinear modelling approach is appropriate if teacher shortages are regarded as the inverse of a truncated index of teacher quality. However, nonlinear models yield biased estimates because the fixed effects are not asymptotically independent of the other coefficients in nonlinear models as first noted by Neyman and Scott (1948). Controlling for cross-section omitted variables is crucial in our setting, as the variable of interest is likely to be correlated with unobserved time-invariant variables. Notice, however, that a linear model with censored observations of the dependent variable will under standard assumptions give bias towards zero in the estimated coefficients. More importantly, if we consider Q as purely an indicator of teacher shortages, it is appropriate to use linear methods since the variable cannot be negative. Estimates of an average effect require that both observations where $Q = 0$ and $Q > 0$ are included in the linear model.

There is considerable variation within local governments. Table 1 shows that the variation within local governments is 42% of the total variation (the square of the difference in standard deviation), and year specific effects and regional trends reduce the variation only by another five percentage points. A crucial requirement for our fixed effects estimation approach to be useful is that the independent variable of interest also has sufficient within regional variation. The variation in regional unemployment is lower than the variation in teacher shortages, and the fixed effects and trend account for 88% of the total variation. The

within variation in manufacturing wages and house prices are substantially lower and may give difficulties for identification.

4.2. Empirical results

Table 2 presents results for several estimated versions of the teacher shortages Eq. (3). For comparison purposes, the first column in Table 2 reports the OLS results when controlling for our teacher demand variables and fixed year effects. This “naïve” specification produces an insignificant positive unemployment effect close to zero. The effects of enrolment per capita and local government revenue per capita are both positive and significant as expected. As discussed above, this specification will likely confound the effect of local variables with unobserved time-invariant local factors affecting both teacher outside opportunities and the general attractiveness of the local government.

The model in column (2) includes in addition fixed local government effects and linear regional trends. Interestingly, in this specification the estimated impact of unemployment is negative and significant at 1% level.²⁷ Evaluating the impact at mean unemployment (2.6%), a one percentage point increase in regional unemployment gives 0.37 percentage points reduction in the share of non-certified teachers. The estimated effects of enrolment and local government revenue are substantially smaller than in column (1), but still statistically significant at 5% level. The estimated effect of local government revenue implies that a 10% rise increases the share of non-certified teachers by 0.2 percentage points. Increasing enrolment per capita by 10 percentage points has an impact of 2.5 percentage points. The effects of the other teacher demand indicators are close to zero in this specification.²⁸

²⁷ Since the time specific effects control for all potential aggregated variables, we expect the unemployment effect to be lower as compared with the time-series results. This intuition is supported by the data. When we estimate the model in column (2) in Table 3 without time specific effects, the effect of the unemployment rate increases with about 50% and is equal to -1.48 which is fairly in line with the unconditional time series evidence on the impact of log unemployment on teacher shortages presented in Footnote 19.

²⁸ It can be argued that the age composition of the current teacher stock may affect the number of vacant teacher positions in the future. Examples are communities with high share of teachers in child-bearing age and communities with a high share of old teachers approaching retirement age. In order to control for such mechanisms, we estimated model versions including two year lags in the share of teachers aged 50 years or older (no measure of teachers even closer to the retirement age is available). This variable is never significant and the effects of unemployment are unchanged. We also estimated model versions including the change in enrolment per capita as an additional explanatory variable. Again, the effect of the new variable is insignificant, and the unemployment effect on teacher shortages is only marginally affected. Detailed results for these specifications can be obtained from the authors on request.

²⁵ The share of non-certified teachers and the share of full-time equivalent non-certified teachers are highly correlated. The correlation coefficient is 0.98 for the time period 1992–2002 where both variables are available. Since the estimates using the share of full-time equivalent non-certified teachers were always close to the corresponding estimates using the share of non-certified teachers, they are not reported below.

²⁶ The vacancy rate is only available at the county level, and the 19 counties represent aggregates of the regional labor markets.

Table 2
Teacher shortages' equations.

	(1)	(2)	(3)	(4)	(5)	(6)
Regional unemployment rate (log)	0.144 (0.576)	−0.946 (0.278)***	−0.893 (0.445)**	−0.883 (0.456)*	−1.305 (0.838)	−1.232 (0.865)
Number of students per capita	42.282 (12.4)***	24.893 (8.14)***	18.265 (11.7)	18.404 (11.7)	46.287 (15.9)***	46.600 (16.2)***
Percent over 80 years of age	−0.213 (0.267)	0.016 (0.181)	0.481 (0.322)	0.483 (0.322)	−0.327 (0.316)	−0.323 (0.314)
Percent with foreign citizenship	−0.503 (0.123)***	0.053 (0.155)	0.308 (0.136)**	0.294 (0.135)**	−0.130 (0.245)	−0.132 (0.245)
Local government revenue (log)	9.041 (1.298)***	2.750 (1.097)**	2.922 (0.929)***	2.982 (0.925)***	3.045 (2.067)	3.060 (2.057)
Manufacturing wages (log)	–	–	−1.703 (1.234)	–	–	–
House prices (log)	–	–	–	–	−0.673 (0.840)	–
Time period	1981–2002	1981–2002	1981–1995	1981–1995	1991–2002	1991–2002
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Fixed local government effects	No	Yes	Yes	Yes	Yes	Yes
Linear regional trend	No	Yes	Yes	Yes	Yes	Yes
Constant	−18.531 (3.528)***	16.185 (3.396)***	9.076 (8.787)	18.278 (7.358)**	37.805 (6.901)***	42.917 (3.318)***
Observations	9718	9718	6690	6690	5205	5205
R-squared	0.225	0.661	0.715	0.715	0.669	0.669

Dependent variable: share of non-certified teachers.

Notes: Robust standard errors corrected for clustering at regional level in parentheses. Regressions are weighted by the number of inhabitants in local government and year. *, **, and *** denote significance at 10, 5 and 1% levels, respectively.

Table 3
Dynamic teacher shortages' equations.

	(1)	(2)	(3)	(4)	(5)
Lagged dependent variable	0.393 (0.020)***	0.300 (0.020)***	0.300 (0.020)***	0.250 (0.028)***	0.251 (0.028)***
Regional unemployment rate (log)	−0.730 (0.220)***	−0.806 (0.347)**	−0.794 (0.355)**	−1.170 (0.709)	−1.116 (0.737)
Number of students per capita	15.051 (5.292)***	7.825 (8.129)	7.923 (8.168)	39.980 (13.29)***	40.201 (13.51)***
Percent over 80 years of age	−0.089 (0.132)	0.179 (0.179)	0.186 (0.180)	−0.135 (0.239)	−0.133 (0.237)
Percent with foreign citizenship	−0.007 (0.130)	0.170 (0.145)	0.155 (0.142)	−0.060 (0.175)	−0.062 (0.175)
Local government revenue (log)	1.921 (0.769)**	2.801 (0.763)***	2.878 (0.760)***	2.442 (1.698)	2.450 (1.691)
Manufacturing wages (log)	–	−1.983 (1.184)*	–	–	–
House prices (log)	–	–	–	−0.507 (0.858)	–
Time period	1981–2002	1981–1995	1981–1995	1991–2002	1991–2002
Year effects	Yes	Yes	Yes	Yes	Yes
Fixed local government effects	Yes	Yes	Yes	Yes	Yes
Linear regional trends	Yes	Yes	Yes	Yes	Yes
Observations	9254	6228	6228	5198	5198
R-squared	0.713	0.743	0.742	0.690	0.690

Dependent variable: share of non-certified teachers.

Notes: Robust standard errors corrected for clustering at regional level in parentheses. Regressions are weighted by the number of inhabitants in local government and year. *, **, and *** denote significance at 10, 5 and 1% levels, respectively.

Columns (3) and (4) in Table 2 present results for the 1981–95 period with and without regional manufacturing wages included in the model. The manufacturing wage turns out to have a negative and insignificant effect, in accordance with the results of the time-series analysis. The effect of unemployment is insensitive to the inclusion of manufacturing wages and the reduction in the sample period. Columns (5) and (6) report the results for the 1991–2002 period with and without regional house prices included in the model. The estimated coefficients of the house price variable are negative, contrary to our expectations, but clearly insignificant. The estimated unemployment effect is largely unaffected by the inclusion of the house price variable, but the effect is less precisely estimated in this sample period.

4.3. Specification checks

In order to investigate the robustness of our estimation results we perform three additional specification checks.

4.3.1. Including dynamics

Because changes in outside opportunities may take time to affect teacher behaviour, it is possible that a static model is misspecified. Table 3 shows the estimation results when the model includes a one year lag in the dependent variable. Column (1) shows that the lagged dependent variable has a clearly significant effect, although it is substantially lower than in the time-series analysis. However, the effect of unemployment does not change much compared to the static model. Evaluated at mean unemployment in the sample, the es-

timated short run (long run) effect of one percentage point increase in regional unemployment is reduced share of non-certified teachers by 0.28 (0.46) percentage points.

For comparison purposes, the rest of Table 3 presents the results for models corresponding to the models in Table 2. In some of these specifications, there are relatively few observations in the time dimensions, which may introduce a bias, see Nickell (1981). Nevertheless, the results are qualitatively similar to the results in Table 2, confirming the evidence that the effect of unemployment is robust both with respect to time periods used and inclusion of alternative wages and house prices.

4.3.2. Using regional vacancies instead of regional unemployment

Table 4 investigates whether teacher shortages are procyclical also with respect to the percentage share of vacancies in the regional labour market. Using regional vacancies introduces some data limitations. First, regional data for vacancies are only available from 1986 on. Second, these data are only reported for the 19 counties, i.e. they are an aggregate measure of the underlying regional vacancies. Table 4 reports the results from model specifications using vacancies instead of unemployment as our independent variable of interest. Interestingly, the effect of vacancies is consistently estimated to be positive, and the effect is significantly different from zero in the baseline specification in column (1). The point estimate is almost identical to the effect of regional unemployment. Using the results in column (1) in Table 4 and evaluating at mean vacancy rate (0.5), the impact of one percentage point rise in the vacancy rate is an increase in the share of non-certified teachers by about two percentage points.

Table 4
Teacher shortages' equations using vacancies instead of unemployment.

	(1)	(2)	(3)	(4)	(5)
Regional vacancy rate (log)	1.046 (0.327)***	0.499 (0.320)	0.505 (0.317)	1.039 (0.760)	1.034 (0.768)
Number of students per capita	39.426 (9.751)***	14.662 (14.35)	14.739 (14.37)	45.780 (15.91)***	45.968 (16.13)***
Percent over 80 years of age	−0.505 (0.282)*	−0.401 (0.358)	−0.400 (0.358)	−0.310 (0.322)	−0.307 (0.320)
Percent with foreign citizenship	0.011 (0.271)	0.408 (0.167)**	0.405 (0.167)**	−0.126 (0.253)	−0.128 (0.254)
Local government revenue (log)	3.980 (1.140)***	4.292 (1.145)***	4.337 (1.134)***	3.035 (2.078)	3.037 (2.063)
Manufacturing wages (log)	–	−0.989 (1.275)	–	–	–
House prices (log)	–	–	–	−0.470 (0.868)	–
Time period	1986–2002	1986–1995	1986–1995	1991–2002	1991–2002
Year effects	Yes	Yes	Yes	Yes	Yes
Fixed local government effects	Yes	Yes	Yes	Yes	Yes
Linear regional trends	Yes	Yes	Yes	Yes	Yes
Constant	15.822 (2.337)***	15.135 (7.475)**	18.960 (5.386)***	39.078 (7.841)***	42.835 (3.121)***
Observations	7448	4420	4420	5205	5205
R-squared	0.681	0.755	0.755	0.669	0.669

Dependent variable: share of non-certified teachers.

Notes: Robust standard errors corrected for clustering at regional level in parentheses. Regressions are weighted by the number of inhabitants in local government and year. *, **, and *** denote significance at 10, 5 and 1% levels, respectively.

4.3.3. Including further controls

Our set of control variables is likely to be incomplete, but the inclusion of fixed effects eliminates all variation in teacher shortages caused by omitted variables that vary across regions but are constant over time. The inclusion of year effects eliminates all influence from omitted factors that varies only over time. Further, the inclusion of regional linear time trends eliminates the influence from unobserved regional variables that evolve smoothly over time. Nevertheless, omitted regional variables affecting both teacher shortages and regional unemployment may still bias the estimated unemployment effect. To illustrate, consider the case with a negative shock in private sector labour demand that causes unemployment in a region to increase. If the shock also decreases teacher demand directly, given our controls, the effect of unemployment on teacher shortages will partly capture this effect and the model will overestimate the impact of unemployment on teacher shortages.

One way to capture such omitted variables given our sample with 22 observations in the time dimension, is to add quadratic regional time trends. In this model specification, the effect of unemployment is identified using within regional variation in unemployment net of regional linear and quadratic time trends.

Although adding quadratic regional trends should account for some of the influence from omitted variables, the ideal solution to the problem with endogenous regional unemployment would be to instrument the unemployment rate using as instruments variables that affect unemployment but do not have a direct impact on teacher shortages. Such instruments are very hard to construct in our case. At the outset, regional policy measures may be considered as instruments, but in reality such policies are also likely to affect teacher demand, i.e., the exclusion restriction is unlikely to hold. An important regional policy instrument in Norway has been geographical differentiation of payroll tax rates paid by employers (including local governments).²⁹ Increased payroll taxes may be thought of as a negative labour demand shock resulting in increased regional unemployment and reduced demand for teachers. In our sample, the tax rate has varied between zero and 17.2%. Although a substantial part of the variation in this tax rate is captured by fixed local government effects and year effects, we add the payroll tax rate as a control variable. The results from specifications including this variable in

addition to the quadratic regional trend are presented in Table 5. We note that the effect of payroll taxes is not significantly different from zero and the estimated effects of unemployment and vacancies on teacher shortages are close to those obtained in the other specifications.

4.4. Gender specific labour market effects?

The preceding sections showed the effects when overall rates of unemployment were used as indicators of the labour market situation. Since a large majority of teachers are women, it maybe argued that labour market conditions for women are most relevant for teacher shortages.³⁰ We therefore constructed gender specific unemployment rates and included these rates in the panel model. The results from this exercise for the baseline model are shown in column (1) in Table 6 and reveal a strong negative and statistically significant effect of female unemployment on teacher shortages, while the impact of the male unemployment rate is positive and insignificant. Columns (2)–(5) show results from several other specifications when the female unemployment rate is included as the only business cycle variable. Compared to the results from versions using the overall rate, the business cycle effect is stronger when the female unemployment rate is used. This evidence confirms the hypothesis that the outside labour market for women asserts a strong impact on teacher shortages. Based on the results in column (2) and evaluating at mean female unemployment rate, the impact of one percentage point increase in female unemployment is a reduction in teacher shortages by 0.52 percentage points, i.e. a somewhat larger effect than found when we used the overall rate. Further, detailed results (available from the authors) show that the negative effect is robust across a number of specifications, and the numerical impact is particularly strong in the second half of the sample period (1991–2002).

5. Concluding comments

The ability of the public sector to recruit skilled workers is an important determinant of the quality of public services as education

²⁹ Norwegian employers are obliged by law to pay a payroll tax as the employers' contribution to the Norwegian National Insurance Scheme. From 1975 on, the municipalities have been classified as belonging to one of 4 zones (5 zones from 1990) with zone 1 as having the highest payroll tax rate, while zone 4 (later zone 5) having the lowest rate. Hence, the payroll tax rate paid by an employer depends on the municipality in which his employees are located. Over time, the central government has changed the tax rates in the different zones and has also to some extent changed the classification of municipalities into zones.

³⁰ In the period 1992–2002, the share of female teachers gradually increased from 64 to 70%. There may be gender differences in teacher responses to external labour market conditions. For example, the propensity to quit a teacher job when outside job availability increases may be higher for males than for females. Similarly, the impact of outside job availability on the probability of students graduating from teacher education to choose a teacher job may be different. The present data do not enable us to identify such differences in behaviour between males and females. The estimated effects presented in this section should be interpreted as the net effect of potential behavioural differences and the mere fact that the majority of teachers are female.

Table 5
Teacher shortages' equations including quadratic regional trends and payroll taxes.

	(1)	(2)	(3)	(4)
Lagged dependent variable		0.370 (0.019)***	–	0.327 (0.026)***
Regional unemployment rate (log)	– 1.076 (0.376)**	– 0.806 (0.330)	–	–
County vacancy rate (log)		–	0.880 (0.346)**	1.110 (0.363)***
Enrolment per capita	29,652 (7.812)***	21,004 (5.044)***	38,197 (10.509)***	29,517 (7.672)***
Percent over 80 years of age	– 0.086 (0.178)	– 0.085 (0.131)	– 0.446 (0.284)	– 0.280 (0.205)
Percent foreign citizenship	0.008 (0.274)	0.077 (0.161)	0.077 (0.250)	0.119 (0.164)
Local government revenue (log)	2.768 (1.012)***	2.368 (0.863)***	4.170 (1.371)***	2.968 (1.007)***
Payroll tax rate (%)	– 0.136 (0.125)	– 0.152 (0.110)	– 0.234 (0.152)	– 0.146 (0.119)
Time period	1981–2002	1982–2002	1986–2002	1986–2002
Year specific effects	Yes	Yes	Yes	Yes
Fixed local government effects	Yes	Yes	Yes	Yes
Linear regional trends	Yes	Yes	Yes	Yes
Quadratic regional trends	Yes	Yes	Yes	Yes
Observations	9718	9254	7448	7438
R-squared	0.675	0.720	0.690	0.723

Dependent variable: share of non-certified teachers.

Notes: Robust standard errors corrected for clustering at regional level in parentheses. Regressions are weighted by the number of inhabitants in local government and year. *, **, and *** denote significance at 10, 5 and 1% levels, respectively.

Table 6
Teacher shortages' equations with gender specific unemployment rates.

	(1)	(2)	(3)	(4)	(5)
Female regional unemployment (log)	– 1.672 (0.516)***	– 1.094 (0.269)***	– 0.812 (0.188)***	– 1.251 (0.380)***	– 0.885 (0.288)***
Male regional unemployment (log)	0.760 (0.462)	–	–	–	–
Lagged dependent variable	–	–	0.390 (0.019)***	–	0.368 (0.019)***
Enrolment per capita	27,141 (8.481)***	26,129 (8.284)***	16,128 (5.388)***	30,100 (7.736)***	21,545 (4.947)***
Percent over 80 years of age	0.037 (0.187)	0.027 (0.183)	– 0.082 (0.131)	– 0.079 (0.179)	– 0.081 (0.132)
Percent foreign citizenship	0.096 (0.121)	0.083 (0.134)	0.011 (0.117)	0.007 (0.262)	0.076 (0.154)
Local government revenue (log)	2.659 (1.044)**	2.616 (1.048)**	1.819 (0.731)**	2.619 (0.919)***	2.283 (0.804)***
Year effects	Yes	Yes	Yes	Yes	Yes
Local government fixed effects	Yes	Yes	Yes	Yes	Yes
Linear regional time trends	Yes	Yes	Yes	Yes	Yes
Quadratic regional time trends	No	No	No	Yes	Yes
Time period	1981–2002	1981–2002	1982–2002	1981–2002	1982–2002
Observations	9718	9718	9254	9718	9254
R-squared	0.662	0.662	0.714	0.676	0.721

Dependent variable: share of non-certified teachers.

Notes: Robust standard errors corrected for clustering at regional level in parentheses. Regressions are weighted by the number of inhabitants in municipality by year. *, **, and *** denote significance at 10, 5 and 1% levels, respectively.

and health services. The traditional model with rigid and centralized national pay systems may lead to serious temporal and regional variations in the ability to recruit workers to public institutions as employment opportunities outside the public sector vary both between regions and over time. Using time-series data from Norway, this paper first shows that public teacher shortages are strongly procyclical. Further, the paper provides empirical evidence on regional imbalances by estimating the impact of regional labour market conditions on teacher shortages using a large panel of Norwegian local governments from 1981 to 2002. Our evidence suggests that a reduction by one percentage point in the regional unemployment rate increases teacher shortages measured by the share of teachers without approved certification by nearly 0.4 percentage points. The evidence is robust with respect to a range of specification tests.

On the other hand, we find no impact on teacher shortages from regional outside wages. This is in contrast to evidence from UK and US suggesting that teachers' occupational choice depends significantly on pay outside teaching. Although this evidence is based on cross sectional data or panel data with a short time period and thus is not directly comparable with our study, different institutional setups may partly explain the different results. Both the US and UK have relatively weak trade unions in the private sector. Scandinavian countries on the other hand have centralized bargaining both in the public and private sectors leaving little room for variation in wages across regions. In such countries quantity signals represented by variation in the unemployment rate or number of vacant jobs outside teaching may provide

more useful information about teachers' outside opportunities than (small) geographical variation in private sector wages.

Appendix A. Data definitions and sources

The time-series data

Teacher shortages: The number of fulltime teachers without approved education divided by the total number of fulltime teachers in primary and secondary public schools in Norway. Registration date 1 October each year. Source, 1973–1991: Education Statistics (NOS Utdanningsstatistikk), several issues, Statistics Norway. Source, 1992–2002: Individual teacher data provided directly from Statistics Norway aggregated to the national level by the authors.

Teacher wage: Average yearly wage for teachers in primary and lower secondary school (Grunnskole), and higher secondary school (Vider-egående skole). Registration date, 1 October each year. Source: Education Statistics (NOS Utdanningsstatistikk), Statistics Norway, several issues.

Private service sector wage: Average yearly wage rate in the private service sector. Source: Grytten (2007).

Data used in the panel data analysis

Dependent variables

Teacher shortages: The number of teachers without approved education divided by the total number of teachers in primary and

lower secondary schools in the local government measured in percent. Registration date is 1 October each year.

Source: From 1981–1991: Norwegian Social Science Data Services (NSD). From 1992–2002 based on individual teacher data provided directly from Statistics Norway aggregated to the local government level by the authors.

Variables measured at the local government level

Local government revenue: Sum of tax income and grants from central government divided by the number of inhabitants as of 1 January each year. Source: NSD.

Percent over 80: Share of inhabitants 80 years or older as of 1 January each year measured in percent. Source: NSD.

Percent foreign: Share of inhabitants with foreign citizenship as of 1 January each year measured in percent. Source: NSD.

Enrolment per capita: The number of students in primary and secondary schools divided by the number of inhabitants as of 1 January each year. Source: NSD.

Payroll tax rate (%): Employers' contribution to the Norwegian National Insurance Scheme calculated as a percentage of wages and remuneration paid for work carried out in Norway. Contributions are differentiated with rates that differ between geographical zones. Source: NSD.

Variables measured at the regional or county level

Percent regional unemployment rate: The average number of registered unemployed persons registered as unemployed at the employment offices each year divided by the number of persons aged 16–66 years 31 December each year. Measured in percent. Source: NSD.

Percent regional vacancies: The average number of vacant jobs registered at the employment offices each year divided by the number of persons aged 16–66 years 31 December each year. Measured as percent at the county level. Source: The Directorate of Labour.

Wages in manufacturing industry: Average wage costs per man-year in manufacturing industry each year. Source: NSD.

Regional house prices: A yearly index constructed from hedonic regressions based on data from registered house transactions where house price per square meter is regressed against house characteristics and regional dummies. The variable can be interpreted as the average price per square meter for a standardized house in each region in a year. Source: Own calculations.

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