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TEACHER SHORTAGES AND THE BUSINESS CYCLE

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Teacher shortages and the business cycle

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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 give limited labor supply and shortages of qualified personnel in areas and periods with strong outside labor 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.

JEL classification: I29, J44, J45
Keywords: Teacher supply, Teacher shortages, Unemployment, Business cycle

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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 labor 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]

The present paper studies the relationship between skill composition in the public sector and the state of the labor market. Public sector labor 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 procyclical, and serious local labor market imbalances with excess demand in some areas and excess supply in other areas might occur as labor market opportunities outside the public sector varies.

Little systematic evidence exists on the extent of cyclical and regional imbalances in public sector labor 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 labor 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.

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[1] See for example Borjas (2003) for 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.

[3] For the effect alternative wages for the teacher labor market, see for example Dolton and van der Klaauw (1995) and Chevalier et al. (2007). For nurses, Elliot et al. (2003) 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

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? In this paper we exploit institutional characteristics in Norwegian primary and lower secondary schools 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 applies a vacant teacher position, and noncertified teachers can only be employed for up to one school year. Thus, the only possible response to shortages of certified teachers is to hire noncertified teachers on short-term contracts. Teacher shortages measured as the share of noncertified teachers thus reflects the state of the teacher labor 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 labor 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 present results for a time-series analysis for the period 1973-2002. By using time-series data one can analyze whether there is a macro effect, and more information on wages exists at the national level than at the regional level. One problematic feature of time-series analyses is that relative wages and teacher shortages are at least in part jointly determined. In a panel data analysis, fixed year effects accounts 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 between local labor markets. Conditional on alternative wages, 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

[4] Bonesrønning, Falch and Strøm (2005) use the same shortage measure to analyze the relationship between teacher sorting and student composition using school level data.

teachers are paid relative to professionals, the less likely are high-quality educated women to choose to be teachers.

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 behavior. Evidence from the UK suggests that the decline in relative teacher wages have 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 labor 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 labor 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 labor market. Section 3 shows time series evidence on the linkage between teacher shortages and the unemployment rate. 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 between national unions and the central government. In the empirical period of 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

[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.
[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 prior to the school year 2002-03.

prevented schools and local governments to use wage and workload policy to attract teachers. Regarding appointments, the school law requires that only persons with a teacher certificate can be employed in permanent positions. Noncertified 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. This means that the number of noncertified teachers relative to total number of teachers can be used as a measure of teacher shortages. Variations in this measure are indeed followed with large attention by commentators and politicians.

Public primary and lower secondary education in Norway (first through tenth grade) is the responsibility of the local governments.[8] The local governments are multipurpose institutions that provide other services in addition to education. Most important is care for the elderly which together with education accounts for 2/3 of local government spending. Student enrolment together with a maximum class size rule that operated within the period of the empirical analysis are key determinants of teacher demand[9]. 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 and considerable income redistribution between local governments through the central government grant system.

2.2. Teacher shortages and teacher quality

Teaching certification in Norway requires either a teacher college degree or a university degree with a certain amount of course work in pedagogy. How well does variation in teacher shortages in general reflect variation in teacher quality? A position as noncertified teacher in

[8] 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 percent in the fall 1992 and 1.9 in the fall 2002.

[9] 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.

the Norwegian institutional setting is not attractive for either the teacher or the school. Noncertified teachers can only be employed on short-term contracts of maximum one school year and only if no individuals with a teaching certificate is interested in the position, and they must therefore expect to look for another job the next school year. For the schools, appointments of noncertified teachers reflect that they are unattractive from the teachers' point of view. Thus, it is reasonable to expect noncertified teachers to have low qualifications and schools employing noncertified teachers to have low student performance.

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. (2007a, 2007b), Goldhaber (2007), and Goldhaber and Anthony (2007). Bonesrønning et al. (2005) report a negative effect of noncertified teachers on student achievement using the PISA2000 sample for Norway.

It is important to notice that noncertified teachers in Norway are typically young with lower experience and less education than certified teachers. For the school year 1998-99, 5.5 percent of the teachers were noncertified. 63 percent of them were below 30 years of age compared to 14 percent among certified teachers, and more than 60 percent had no more than high school education.[10] During the period 1992-2002, only about 40 percent of the noncertified teachers stay at the same school in two consecutive years. In particular the low age of noncertified teachers is important because the evidence clearly indicate that novice teachers are less productive than experienced teachers in terms of student achievement (Hanushek, 2006).

2.3. Theoretical framework

We start with a simple aggregate model of the teacher labor 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:

[10] These numbers are similar for the whole period for which we have individual data, the school years 1992-93 to 2002-03.

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

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

where Q is teacher shortages, W is the teacher wage, $\overline{W}$ 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. Equation (1) is the wage setting curve, where we assume that a_1 is positive, i.e. high teacher shortages increases the teacher relative wage. This assumption is consistent with bargaining theories of wage determination since teacher wage claims is likely to increase in times with teacher shortages where the risk of being unemployed is low.[11] The more market oriented the teacher wage setting is, the higher is the elasticity of relative teacher wages with respect to shortage.

Equation (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 increases 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 expected payoff as a teacher relative to alternative employment increases.

Figure 1 gives a graphical representation of the model where the WW-curve represents equation (1) and the QQ-curve represents equation (2). The figure illustrates how changes in the unemployment rate may affect wages and teacher shortages at the national level in this model. 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, for given teacher shortages, depends on whether teacher wages or the alternative wages are most responsive with respect to unemployment fluctuations. Figure 1 assumes that teacher wages are least responsive ($a_2 < 0$), shifting the WW-curve upwards from WW^0 to WW^1. The

[11] 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 equation (1).

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 equation (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 identification of the QQ curve. This is our first empirical strategy. Our second 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 might still bias the estimated unemployment effects on teacher shortages. In section 4 we discuss this problem and possible solutions.

3. Time-series analysis

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. If higher relative teacher wages reduce teacher shortages significantly, teacher wages will be an important policy instrument. In this section we use teacher wages relative to the wage rate in private services[12].

Figure 2 shows the development in aggregate teacher shortages, Q, the aggregate unemployment rate, U, and the relative wage, $WR = W/\bar{W}$ during the period 1973-2002. The share of uncertified teachers varies between one and seven percent, and shows a marked

[12] See Appendix for further definitions and sources of the variables used in this section.

downward sloping trend in the 1970's when the unemployment rate was low and stable.[13] However, both the unemployment rate and the teacher shortage rate started to fluctuate significantly from the early 1980's on. In particular, the development of the share of uncertified teachers shows a remarkable procyclical pattern. The relative wage shows a downward trend until the end of the 1990's for thereafter to increase slightly. However, the relative teacher wages *fluctuates* much less than teacher shortages and the unemployment rate.

The cyclical pattern in teacher shortages is confirmed by Figure 3 which presents a cross-plot between Q and U along with the fitted regression line. The slope along the regression line is -0.76 with a t-statistic of -5.10 (R^2 = 0.48). Taken at face value, this means that an increase in the aggregate unemployment rate by one percentage point will reduce the share of uncertified teachers by 0.76 percentage points.[14]

After this first rough indication that aggregate teacher shortages are significantly influenced by the aggregate unemployment rate, we turn to a more formal time series analysis. To do so we formulate a baseline dynamic model of the teacher shortages given by

$$(3) \qquad Q_t = \alpha Q_{t-1} + \beta_1 \ln WR_t + \beta_2 \ln WR_{t-1} + \beta_3 \ln U_t + \beta_4 \ln U_{t-1} + \beta_5 \Delta \ln Stud_t + \beta_0 + v_t,$$

where Q_t is the percentage share of teachers without formal qualifications, WR_t is teachers wages relative to wages in the private service sector, U_t the unemployment rate (in per cent) and $Stud_t$ the number of students. The growth rate of students is included to capture a demand side effect as high student growth will increase demand for teachers, and thus might increase teacher shortages. Results based on equation (3) are presented in Table 1 where columns (1) and (2) report OLS-estimates, whereas columns (3) – (5) report instrumental variable estimates where the relative wage is treated as endogenous.

For all specifications reported in Table 1, both OLS- and IV-estimation indicate a negative and significant short run effect of unemployment. Using OLS, the implied long-run effects of

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

[14] 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 -2.23 with t-statistic of -7.60 and R^2 =0.67.

unemployment are border case significant and very similar to the corresponding short-run effects. The OLS-estimates of the relative wage effects are negative, but very small and highly insignificant both in the short and in the long run. The OLS-estimates imply a positive effect of student growth on teacher shortages whereas the IV-estimate in column (3) is negative. In both cases, the estimated effects are statistically insignificant, and excluding student growth from the model does not influence the main results, cf. column (2) and (4).

The theoretical model implies that the relative wage is endogenous in equation (3) because teacher wages are affected by teacher shortages. This suggests that the OLS estimate of the relative wage effect is biased towards zero. We therefore estimate the models using the instrumental variable method treating the relative wage as endogenous. The additional instruments used in the estimation are current values and the first lag of private service labor productivity and the second lag of the unemployment rate (all in logs). As can be seen from column (3) and (4), the IV-estimates imply increased relative wage effects compared to the OLS-estimates both in the short run and in the long run. However, the estimated relative wage effects are still statistically insignificant and rather small. For example, the long run estimate in column (3) implies that a relative wage increase by 10 per cent will reduce teacher shortages by 0.88 percentage points.

The estimated unemployment effects is somewhat stronger when the relative wage is instrumented compared with the OLS-estimates. To illustrate the importance of the unemployment effect we use the long run estimate in column (3). If the unemployment rate increases from 1.5 to 5.5 percent, corresponding to the observed increase from 1987 to 1993, teacher shortages is reduced by about 3 percentage points.

Figure 1 reveals long run trends both in teacher shortages, the unemployment rate and the relative wage. A potential critique is therefore that our results so far are driven by common trends. As a final sensitivity check we therefore expand the baseline model with a quadratic time trend. The results based on the expanded model reported in column (5) imply even stronger unemployment effects – in particular in the long run. On the other hand, the long run relative wage effect is barely affected whereas the short run effect is reduced (in absolute value).

To conclude, the time series analysis demonstrates a strong procyclical pattern in teacher shortages, and indicates that teacher relative wages have a small impact.[15] However, a problem with this approach is the short 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 labor market caused by the centralized nature of teacher wage setting.

4. Panel data analysis

4.1 Model specification and data

The empirical counterpart to the teacher shortages equation (2) for local governments, which are responsible for the schools and determine teacher demand, can be written

$$(4)\quad Q_{it} = b_1 \ln \overline{W}_{jt} + b_2 \ln U_{jt} + b_3 D_{it} + b_4 S_{it} + b_{5j} t + \eta_i + \delta_t + \varepsilon_{it}$$

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 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.[16] 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.

Several of the Norwegian local governments are small with less than 5000 inhabitants, for which the local labor market is likely to go beyond the local government borders. It is not straightforward to define the borders of local labor markets. Based on worker commuting

[15] The same conclusion holds using manufacturing wages as an alternative measure of the alternative wage.
[16] 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.

statistics, Statistics Norway has classified 90 different labor market areas consisting on average of 4.8 local governments. We use this classification, and include unemployment U_{jt} and the alternative wage $\overline{W}_{jt}$ in labor 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 labor market variables are measured at the regional labor 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.

It is problematic to create consistent series of regional wages in Norway for our empirical period 1981-2002. For the period 1981-1995, we include a measure of the regional average wage in manufacturing industry. For the period 1991-2002, we include an index of regional house prices.[17] If regional private sector wages fluctuate with house prices, including house prices should account for a substantial variation in teachers alternative wages.

Ideally, we want to include a measure of the wage a teacher would receive if employed in a non-teacher job. 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) reports 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 (2005b) estimate much smaller and mostly insignificant effects of regional unemployment on local government wages (excluding teachers). To the extent that the relevant alternative labor market for teachers is other local government jobs, this evidence suggest that the bias from excluding measures of alternative wages is quite small. In addition, the time series analysis above indicates that alternative wages are not important for teacher shortages.

[17]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.

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 have the right to receive additional instruction resources.[18]

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 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 full-time equivalent teachers, but this measure is available only for the period 1992-2002.[19]

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.[20] 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.

Table 2 presents descriptive statistics. The unweighted average share of noncertified teachers is 6.2 percent and varies from zero to 64 percent. Teacher shortages are absent in 20 percent of the observations. This suggests that a nonlinear modeling approach is appropriate if teacher shortages are regarded as the inverse of a truncated index of teacher quality. However,

[18] These variables are the standard variables included in demand studies of Norwegian local governments.

[19] The share of noncertified teachers and the share of full-time equivalent noncertified 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 noncertified teachers were always close to the corresponding estimates using the share of noncertified teachers, they are not reported below.

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

nonlinear models yields biased estimates because the fixed effects are not asymptotically independent of the other coefficients in non-linear 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 2 shows that the variation within local governments is 42 percent of the total variation (the square of the difference in standard deviation), and year specific effects and regional trends reduces 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 in teacher shortages, and the fixed effects and trend account for 88 percent 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 3 presents results for estimations of the teacher shortages equation (4). For comparison purposes, the first column in Table 3 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 one percent level. The effect is about the half of our finding in the

time-series analysis, but still of substantial numerical size.[21] Evaluating the impact at mean unemployment (2.6 percent), a one percentage point increase in regional unemployment gives 0.37 percentage points reduction in the share of noncertified teachers. The estimated effects of enrolment and local government revenue are substantially smaller than in column (1), but still statistically significant at five percent level. The estimated effect of local government revenue implies that a 10 percent rise increases the share of noncertified 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.

Columns (3) and (4) in Table 3 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 tests

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

Including dynamics

Because changes in outside opportunities may take time to affect teacher behavior, it is possible that a static model is misspecified. The time-series analysis clearly indicates a dynamic adjustment of teacher shortages. Table 4 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

[21] 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 percent and is equal to -1.48.

compared to the static model. Evaluated at mean unemployment in the sample, the estimated short run (long run) effect of one percentage point increase in regional unemployment is reduced share of noncertified teachers by 0.28 (0.46) percentage points.

For comparison purposes, the rest of Table 4 presents the results for models corresponding to the models in Table 3. 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 3, 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.

Using regional vacancies instead of regional unemployment

Table 5 investigates whether teacher shortages are procyclical also with respect to the percentage share of vacancies in the regional labor 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 5 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 in most specifications it turns out to be significantly different from zero. The point estimate is almost identical to the effect of regional unemployment. Using the results in column (1) in Table 5 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 noncertified teachers by about two percentage points.

Including both linear and quadratic regional time trends

So far, we have included regional linear time trends to account for smooth temporal variation in unobserved variables. Since we have a panel with 22 observations in the time dimension (using the whole sample) it is also possible to specify a more flexible functional form. Adding quadratic regional time trends should take care of a substantial part of smooth temporal variation in unobserved alternative wages and other unobserved variables. Table 6 reports the results from estimating different specifications of the teacher shortages equation with both linear and quadratic regional trends included. We estimate both dynamic and static versions and versions using vacancies instead of unemployment as the business cycle indicator. We

notice that the estimated impacts of the business cycle variables are close to those obtained above. Thus, it is reassuring that the evidence seem robust to controlling for a large amount of unobservables.

4.4. Gender specific labor market effects?

The preceding sections showed the effects when overall rates of unemployment were used as indicators of the labor market situation. Since a large majority of teachers are women, it may be argued that labor market conditions for women are most relevant for teacher shortages.[22] 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 7 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. Column (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 labor 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 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

[22] In the period 1992-2002, the share of female teachers gradually increased from 64 to 70 percent. There may be gender differences in teacher responses to external labor 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 does 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.

public sector varies both between regions and over time. This paper first shows using time-series data from Norway, that public teacher shortages are strongly procyclical. Further, the paper provides empirical evidence on regional imbalances by estimating the impact of regional labor 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 an US suggesting that teachers' occupational choice depends significant 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.

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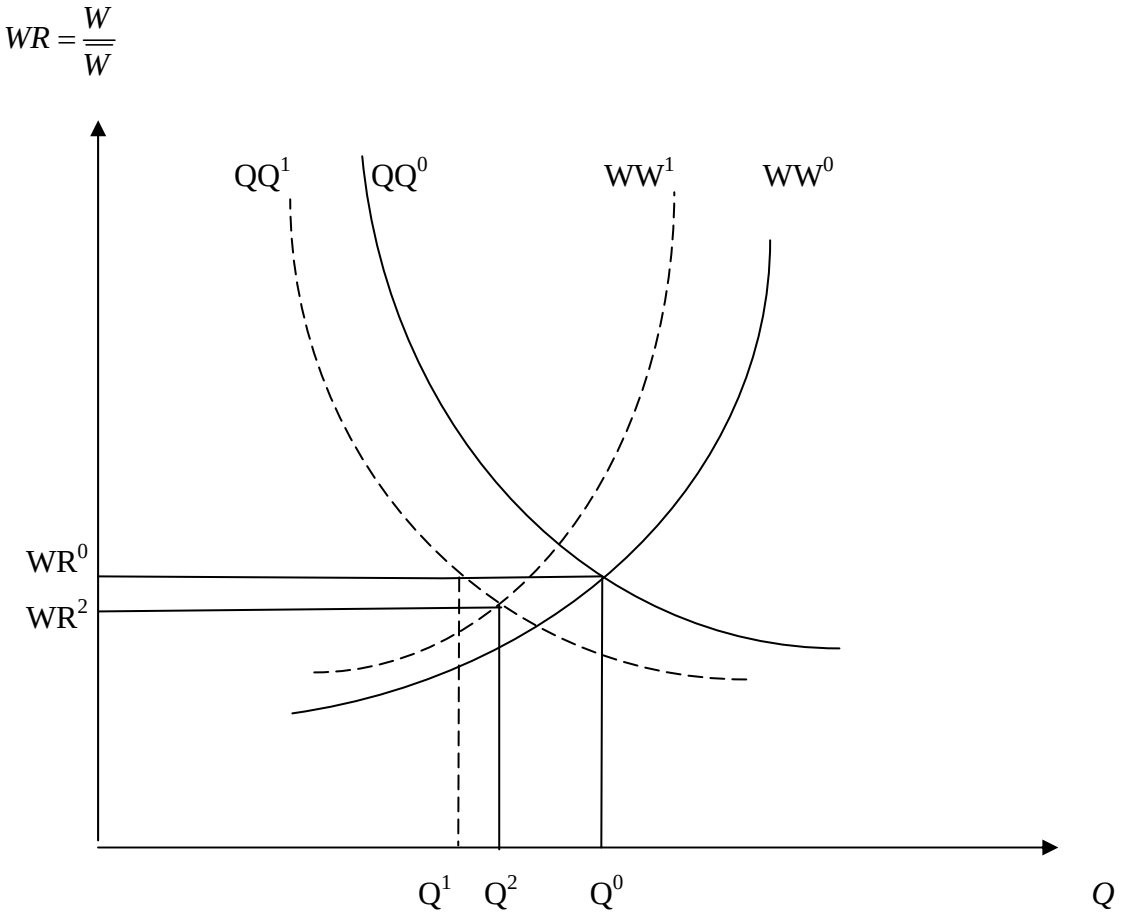
Figure 1. Teacher relative wage and teacher shortage.



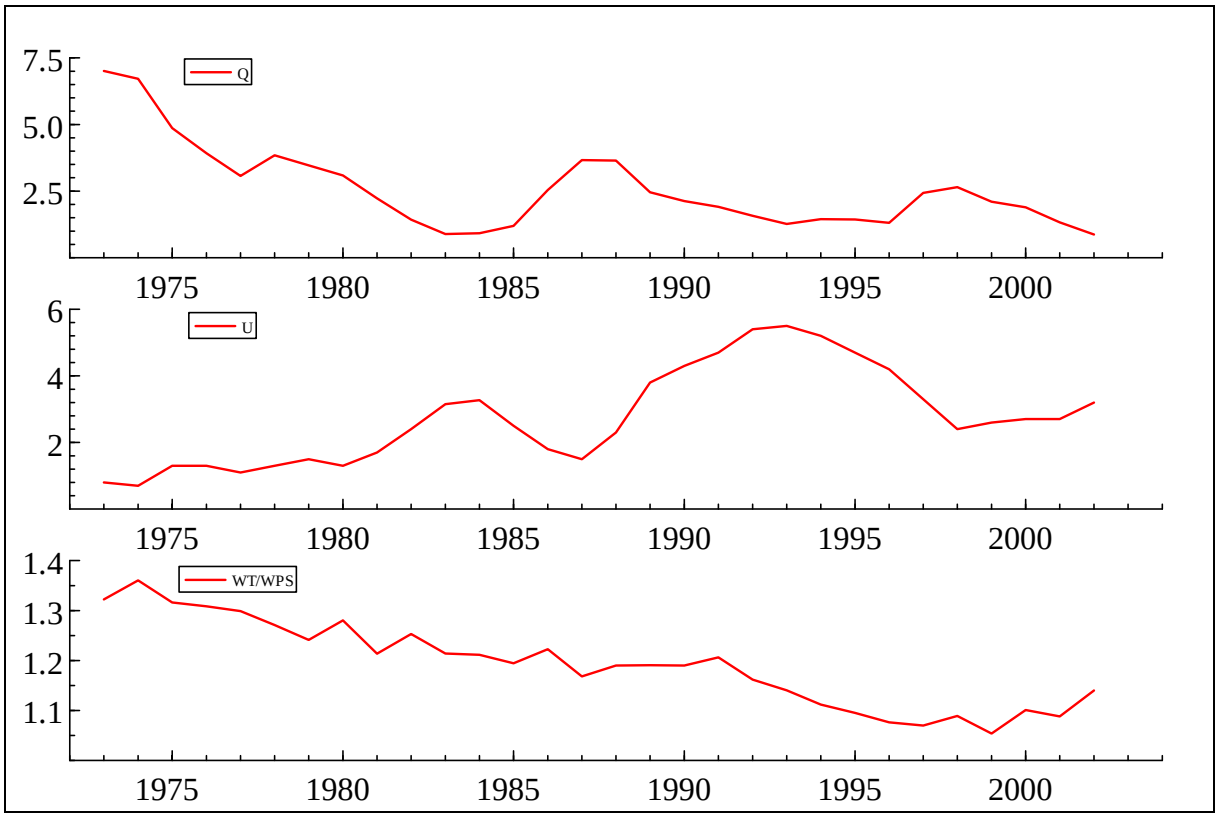


Figure 2. The share of noncertified fulltime teachers, Q, the unemployment rate, U, and relative teachers' wage, WR=WL/WPS, 1973 – 2002.

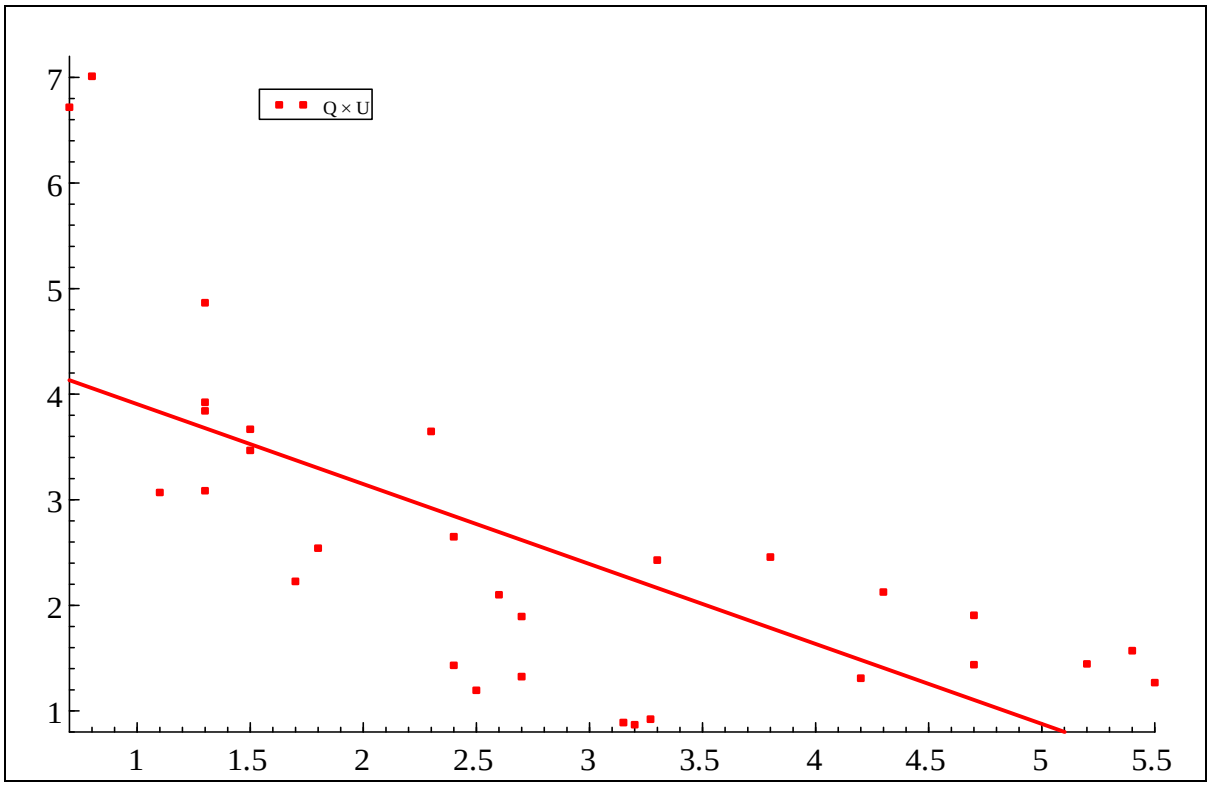


Figure 3. Scatter plot of share of noncertified fulltime teachers against unemployment rate with fitted line, 1973 – 2002.

Table1. Time series analyses of teacher shortages 1974 – 2002. Dependent variable is the share of fulltime noncertified teachers (Q_t).

Variables	(1) OLS	(2) OLS	(3) IV	(4) IV	(5) IV
Q_{t-1}	0.732	0.743	0.758	0.752	0.834
	(0.12)	(0.110)	(0.12)	(0.11)	(0.11)
$\ln WR_t$	-0.562	-0.958	-6.932	-6.577	-3.549
	(4.28)	(4.00)	(6.10)	(5.85)	(6.89)
$\ln WR_{t-1}$	0.373	0.368	4.813	4.700	2.473
	(3.71)	(3.64)	(4.84)	(4.94)	(5.19)
$\ln U_t$	-1.645	-1.686	-1.795	-1.772	-2.006
	(0.46)	(0.43)	(0.49)	(0.46)	(0.47)
$\ln U_{t-1}$	1.204	1.238	1.226	1.210	1.019
	(0.53)	(0.51)	(0.56)	(0.53)	(0.49)
$\Delta \ln Stud_t$	1.180		-0.599		4.742
	(3.91)		(4.26)		(4.76)
trend					0.375
					(0.20)
$trend^2$					-0.006
					(0.003)
Const	0.510	-0.437	-3.931	-3.369	-6.313
	(5.90)	(4.90)	(6.82)	(5.53)	(15.93)
		Long run estimates			
$\ln WR$	-0.704	-2.294	-8.759	-7.585	-6.467
	(9.63)	(8.53)	(14.31)	(10.91)	(48.81)
$\ln U$	-1.643	-1.740	-2.348	-2.266	-5.938
	(1.03)	(1.01)	(1.36)	(1.17)	(3.80)
		Diagnostics			
$\hat{\sigma}$	0.516	0.505	0.541	0.527	0.462
AR	1.214	0.624	0.304	0.347	0.288
Sargan			5.974	6.055	3.064
First stage F			7.96	7.20	4.50

Notes: Estimated coefficients with estimated standard errors in parentheses. $\hat{\sigma}$ is the estimated standard error of the regression, AR is an F-test of first and second order autocorrelation in the residuals, Sargan is the Sargan test of instrumental validity, and the First stage F is an F-test of joint significance of the additional instruments in the first stage regression. The endogenous explanatory variable that is instrumented is $\ln WR_t$.

Table 2. 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	Obser-vations
Percent noncertified teachers	6.28	0	63.64	6.72	4.34	4.13	9761
Percent noncertified 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 manyear in manu-facturing 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 ≈ 18 US$

Table 3. Teacher shortages equation. Dependent variable is the share of noncertified teachers

	(1)	(2)	(3)	(4)	(5)	(6)
Regional unemployment rate (log)	0.144	-0.946	-0.893	-0.883	-1.305	-1.232
	(0.576)	(0.278)***	(0.445)**	(0.456)*	(0.838)	(0.865)
Number of students per capita	42.282	24.893	18.265	18.404	46.287	46.600
	(12.4)***	(8.14)***	(11.7)	(11.7)	(15.9)***	(16.2)***
Percent over 80 years of age	-0.213	0.016	0.481	0.483	-0.327	-0.323
	(0.267)	(0.181)	(0.322)	(0.322)	(0.316)	(0.314)
Percent with foreign citizenship	-0.503	0.053	0.308	0.294	-0.130	-0.132
	(0.123)***	(0.155)	(0.136)**	(0.135)**	(0.245)	(0.245)
Local government revenue (log)	9.041	2.750	2.922	2.982	3.045	3.060
	(1.298)***	(1.097)**	(0.929)***	(0.925)***	(2.067)	(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	16.185	9.076	18.278	37.805	42.917
	(3.528)***	(3.396)***	(8.787)	(7.358)**	(6.901)***	(3.318)***
Observations	9718	9718	6690	6690	5205	5205
R-squared	0.225	0.661	0.715	0.715	0.669	0.669

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 *** denotes significance at one, five and ten percent level, respectively.

Table 4. Teacher shortages equations. Dependent variable: share of noncertified teachers

	(1)	(2)	(3)	(4)	(5)
Lagged dependent variable	0.393	0.300	0.300	0.250	0.251
	(0.020)***	(0.020)***	(0.020)***	(0.028)***	(0.028)***
Regional unemployment rate (log)	-0.730	-0.806	-0.794	-1.170	-1.116
	(0.220)***	(0.347)**	(0.355)**	(0.709)	(0.737)
Number of students per capita	15.051	7.825	7.923	39.980	40.201
	(5.292)***	(8.129)	(8.168)	(13.29)***	(13.51)***
Percent over 80 years of age	-0.089	0.179	0.186	-0.135	-0.133
	(0.132)	(0.179)	(0.180)	(0.239)	(0.237)
Percent with foreign citizenship	-0.007	0.170	0.155	-0.060	-0.062
	(0.130)	(0.145)	(0.142)	(0.175)	(0.175)
Local government revenue (log)	1.921	2.801	2.878	2.442	2.450
	(0.769)**	(0.763)***	(0.760)***	(1.698)	(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

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 *** denotes significance at one, five and ten percent level, respectively.

Table 5. Teacher shortages equations using vacancies instead of unemployment. Dependent variable: Share of noncertified teachers

	(1)	(2)	(3)	(4)	(5)
Regional vacancy rate (log)	1.046	0.499	0.505	1.039	1.034
	(0.327)***	(0.320)	(0.317)	(0.760)	(0.768)
Number of students per capita	39.426	14.662	14.739	45.780	45.968
	(9.751)***	(14.35)	(14.37)	(15.91)***	(16.13)***
Percent over 80 years of age	-0.505	-0.401	-0.400	-0.310	-0.307
	(0.282)*	(0.358)	(0.358)	(0.322)	(0.320)
Percent with foreign citizenship	0.011	0.408	0.405	-0.126	-0.128
	(0.271)	(0.167)**	(0.167)**	(0.253)	(0.254)
Local government revenue (log)	3.980	4.292	4.337	3.035	3.037
	(1.140)***	(1.145)***	(1.134)***	(2.078)	(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	15.135	18.960	39.078	42.835
	(2.337)***	(7.475)**	(5.386)***	(7.841)***	(3.121)***
Observations	7448	4420	4420	5205	5205
R-squared	0.681	0.755	0.755	0.669	0.669

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 *** denotes significance at one, five and ten percent level, respectively.

Table 6. Teacher shortages equations including quadratic regional trends. Dependent variable is the share of noncertified teachers.

	(1)	(2)	(3)	(4)
Lagged dependent variable	-	0.370	-	0.328
		(0.019)***		(0.026)***
Regional unemployment rate (log)	-1.089	-0.825	-	-
	(0.373)***	(0.329)**		
County vacancy rate (log)	-	-	0.939	1.142
			(0.359)**	(0.372)***
Enrolment per capita	30.075	21.438	38.919	29.964
	(7.748)***	(4.911)***	(10.16)***	(7.40)***
Percent over 80 years of age	-0.082	-0.083	-0.455	-0.285
	(0.178)	(0.131)	(0.286)	(0.206)
Percent foreign citizenship	0.005	0.075	0.076	0.119
	(0.274)	(0.161)	(0.251)	(0.164)
Local government revenue (log)	2.787	2.385	4.205	2.987
	(1.014)***	(0.867)***	(1.385)***	(1.014)***
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

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 *** denotes significance at one, five and ten percent level, respectively.

Table 7. Teacher shortages equations with gender specific unemployment rates. Dependent variable is the share of noncertified teachers.

	(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

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 *** denotes significance at one, five and ten percent level, respectively.

Appendix 1: Data definitions and sources.

Data used in the time series analysis

Teacher shortage: 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 (Videregående 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).

Labor productivity in private service sector: Yearly value added per manyear in private service sector. Source: National accounts. Statistics Norway.

Unemeployment rate: The average number of registered unemployed persons divided by the labour force. Source: Statistical yearbook, Statistics Norway, several issues.

Students: Total number of students in primary and lower secondary school. Source: Education Statistics (NOS Utdanningsstatistikk), Statistics Norway, several issues.

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: 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

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 manyear 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.