The Determinants of Teacher Supply: Time Series Evidence for the UK, 1962-2001.

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Abstract

This paper examines the determinants of aggregate teacher supply in the UK using time series data. Teacher supply is measured by: the wastage rate, i.e. the rate of teachers leaving the teaching market; the change in the pool of inactive teachers; and the proportion of graduates entering initial teacher training programmes. We model the proportion of graduates enrolling for initial teacher training programmes by 4 major faculty groupings: Social Science; Arts; Pure Science; and Applied Science. The results show unemployment and relative wages to be important determinants of teacher supply. Another aspect found to be important for prospective teachers is the security of a teaching position on graduating from their training programmes.

JEL Classification: J21, J23, J48

Keywords: Teacher supply, Initial Teacher Training, relative wages

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1. Introduction

Problems with the supply of teachers continue to generate considerable national concern. Government, educationalists, schools, teachers and parents are justifiably at the centre of the policy debate over teacher supply. Yet paradoxically there has been relatively little careful analysis of the changes in this market over time. Much media attention has focussed on the relatively poor pay of teachers and the changing working conditions in teaching. There is also some limited recognition that young graduates may think about the option of becoming a teacher differently in times of high graduate unemployment from when alternative graduate opportunities are plentiful. There has been something of a paucity of quality evidence to link these observations. We specifically wish to examine the link between the economic labour market conditions, in terms of relative teacher earnings and graduate unemployment, and the nature of aggregate teacher supply.

In the teacher labour market literature[1], much of the empirical work has relied on results from occupational choice models utilising cross section data. This research focuses on the available time series evidence for the UK. Such analysis is possible since there is extremely good time series annual data on most of the variables of interest from 1960 onwards. These data have hitherto only been examined by Zabalza (1979) over the 1963-1971 period. Using the possibility of distinguishing between male and female teacher labour markets and observing that the market for potential teachers is different by subject area, we can exploit existing data to estimate a time series teacher supply model.

This paper presents econometric results from modelling three different concepts of teacher supply. The measurement of teacher supply does not prove a straightforward task, given its broad definition encompassing various sub-groups of personnel. We

[1] All the studies quoted in this paper refer to England and Wales. The Scottish and Northern Ireland systems are different and data are more readily available on the teacher labour market in England and Wales.

discuss this issue further in section 3. In this paper, we shall specifically consider what has happened to: teacher wastage; the size of the pool of inactive teachers; and the proportion of new graduates entering teacher training. These are three measurable indicators of the supply of teachers. We show how each of these supply measures is influenced (positively) by the size of teacher relative pay and the level of new graduate unemployment. Such findings strongly support the available economic models of occupational choice (see Dolton 2003 for a review of these theories for the teacher labour market), which predict that teacher supply would be higher if graduate unemployment is higher and/or teachers' relative pay is better.

This paper provides an up to date study of the determinants of teacher supply in the long run by updating the time series empirical work that is currently available using a set of time series, cross section data from 1960 to 2001. Section 2 provides a brief review of the empirical work that is available on the teacher labour market. In Section 3, we describe the labour market for teachers and teacher supply conditions in the UK, while in Section 4, we discuss the modelling of time series data to examine the determinants of teacher supply. Section 5 details the estimation results obtained and Section 6 concludes.

2. Existing Empirical Work on the Teacher Labour Market

The available cross section empirical work ((Dolton and Mavromaras 1994, Dolton and Van der Klaauw 1995, 1999 and Chevalier *et al.* 2001) allows us to identify the possible causes of teachers leaving the profession in the short term while the use of time series data on the teacher labour market may give us an opportunity to understand the influences of the different economic factors causing teachers to leave or enter the profession in the longer term. In the majority of studies, relative wages have been found to be the main influence of teachers leaving and entering the sector. For example, in Dolton and van de Klaauw (1995, 1999), it is found that a higher teaching wage reduces the probability of a teacher leaving the labour force altogether, while a higher predicted wage in the non-teaching sector is related to an increased likelihood of moving into a non-teaching job.

An earlier study, based only on time series data at the aggregate level in the UK for the years 1963-1971 (Zabalza, *et al.* 1979) provided estimates of the elasticity of teacher labour supply with respect to relative teacher earnings. The estimated values range from 2.4-3.9 for men and from 0.3-1.8 for women, depending on the definition of alternative wages used. When teaching wages are split into starting wages and wage growth, the authors find that the effect of the relative level of starting wages in teaching is similar for both sexes, while the effect of teacher wage growth over time is much greater for men. This suggests that the wage effects are greater for men primarily because wages appear to play a relatively more important role in their careers.

In Zabalza (1979),[2] an occupational choice model was used to examine the determinants of teacher supply. In this model, both the starting wages and future earnings prospect of teacher wages and alternative occupations were included in addition to other non-pecuniary consideration, such as the employment probability of the two occupations. This paper examined both the entry and exit decision using a set of time series data[3] on new entrants of graduate teachers and leavers (both graduate and non-graduate teachers) by gender. Zabalza found that both male and female new entrants are sensitive to changes in relative wages and unemployment. Prospective earnings profiles were also a significant determinant of teacher supply in the UK. When it came to the leavers, male graduate teachers were more sensitive to the changes in earnings prospects and also to starting salaries. While the female leavers were less sensitive to changes in earnings, they were influenced by the unemployment level in the economy.

Court, *et al.* (1995) made an attempt to extend and update Zabalza's time series work by utilising a similar set of measures for the years 1986 to 1992. In Court, *et al.*'s work, the effect of relative starting salary was found to be positive and significant, while the other

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[2] This paper was also included as a chapter in Zabalza, *et.al* (1979)

[3] Zabalza used a set of data dating from 1963 to 1971, cross sectioned by 5 subject divisions (namely Sciences, Other Sciences, Modern Languages, Classics and miscellaneous subjects) and gender while in the examination of the determinants of leavers, he used a time series set of data from 1963 to 1972 by age group and by gender.

variables found significant in Zabalza's paper did not appear to be important in Court, *et al.*'s update.

Other time series work examining the teacher labour market in the UK include Bee and Dolton (1995) and Dolton and Robson (1996). Bee and Dolton (1995) found that excess demand had a significant role to play in the determination of teachers' salary. In the paper by Dolton and Robson (1996), teacher wage bargaining effects were found to be influenced by the concentration of teacher membership (as measured by the Herfindahl index). In a more recent report to the OECD (Dolton, et al., 2003), using a set of UK time series data dating from 1955 to 2000, evidence of a relationship between teacher supply and the economic cycle was found. The evidence shows that this relationship works through relative wages and unemployment changes rather than through real GDP per se.

Dolton (1990) uses data from the 1980 Graduate Cohort, which follows a sample of graduates for up to seven years after they have graduated. As elsewhere, wages are shown to be an important factor in the decision to become a teacher. Specifically, relative starting wages in teaching (compared to estimated potential earnings elsewhere) are positively related to the probability of becoming a teacher. In addition, individuals are more likely to become teachers the greater the growth over time in teachers' earnings, and the lower the growth in earnings of non-teachers.

Other papers utilising cross section data include Dolton and van der Klaauw (1995a, 1995b, 1999) and Dolton and Mavromaras (1994). These papers report findings of a positive correlation between wages in the non-teaching sector and the probability of teachers leaving the teacher labour force. In Dolton and Mavromaras (1994), comparisons over time were made using the 1970 and 1980 graduate cohort data sets. The authors decomposed the cause of the fall in the likelihood of becoming a teacher between these two dates to changes in the characteristics of the individuals themselves, and changes in the characteristics of the job market that they face. The results reveal that the fall is due almost entirely to deteriorating market conditions for teachers.

3. Teacher Labour Market and Teacher Supply in the UK

Determining demand for teachers is relatively straightforward as demand is dependent on the number of pupils in the country and on the Government's desired pupil-teacher ratio (PTR). The higher the number of pupils enrolled in schools along with a lower PTR target set by the Government will boost demand for teachers. It is the measuring of the supply of teachers, which is more problematic.

The supply of teachers can be divided into the current supply component and the potential supply component. The number of teachers currently in service forms the current supply component and this includes teachers who are new entrants into the market and those re-entering the teacher labour market after a spell of being out of the teacher labour market. The re-entrants include female teachers who left the teaching profession temporarily for purposes such as giving birth to and/or raising children. It also includes teachers who were previously in service and had moved to another position, either in the non-teaching sector or to the private teaching sector. Teacher wastage, or attrition, in any period is removed from supply figures to acknowledge outflow from the teaching labour market. The number of teachers in service, entrants, re-entrants and teacher wastage are directly quantifiable as the Government collects and reports reliable data on these measures annually.

The supply of teachers is potentially enhanced by the existence of the pool of inactive teachers, i.e. persons who are qualified to teach but do not enter teaching or teachers who have taught previously but have left and decided to not to return to teaching. A subset of these inactive teachers is the pool of recoverable teachers, i.e. those who may be attracted back into the profession. Members of this pool may return as full-, or part-time service teachers or as temporary teachers. There are other smaller components contributing to the stock of teacher supply such as supply teachers; these constituted about 4% of all teachers in 2002. In the late 1990s, the recruitment of teachers from overseas holding temporary teaching positions became commonplace to fill shortages of teachers in the UK (Ross and Hutchings, 2003).

Figure 1 displays the number of teachers serving in the UK from 1947 to 2000 while Figure 2 shows the rate of teachers leaving the profession from 1959 to 2000 expressed as the number of early leavers (i.e. teachers who leave prior to attaining the age of retirement) as a fraction of the total number of teachers in service. In Figure 1, although the male and female teacher supplies exhibit similar patterns, the number of female teachers is always higher than that for males. It is also evident from the plot that the levels of teacher supply reached a peak in the early 1980s and have since declined.

Figure 1: Teachers in service in the UK, 1947-2000

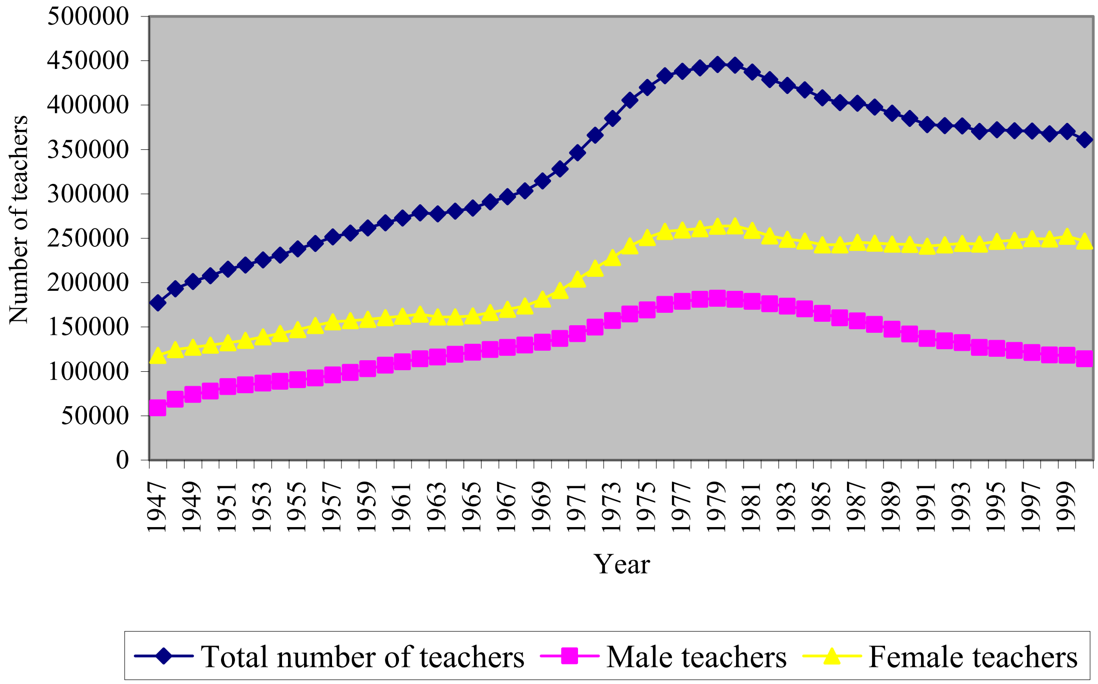
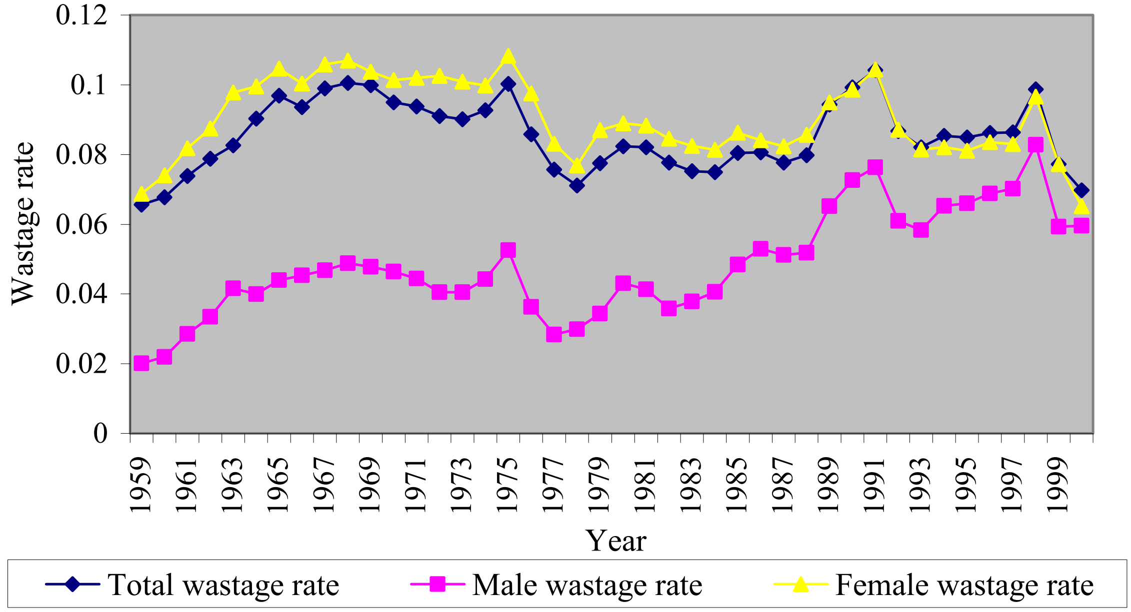


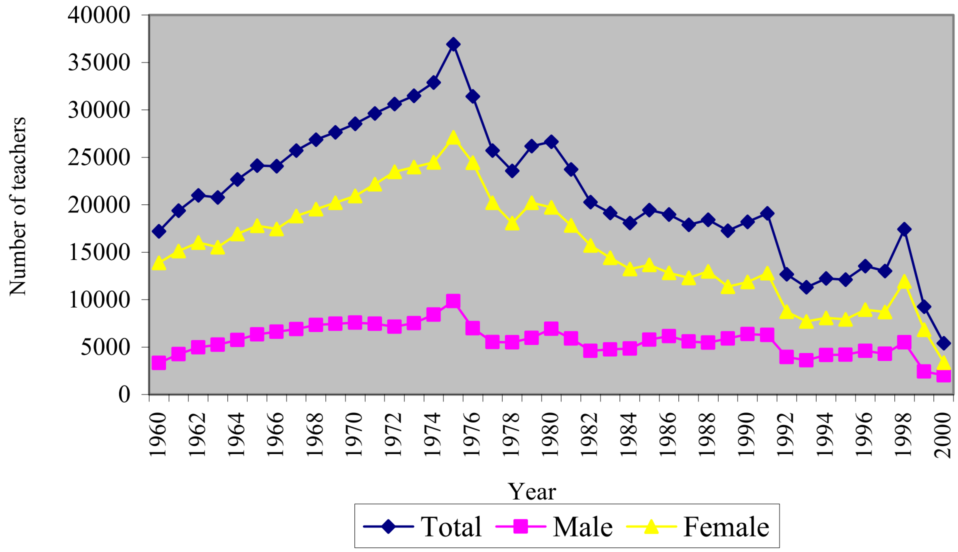
Figure 2: Teacher wastage rate in the UK, 1959-2000



Turning to wastage rates, it is clear that, over the 40 years or so for which data are available, attrition rates have consistently been in the range 7%-10% per annum for women, whereas the comparable figures for men have systematically increased from just over 2% to around 7% or 8% in recent years. It may be the case that the difference in the series for men and women is due to women leaving the profession to have career interruptions for family reasons.

Figure 3 displays the change in the total pool of inactive teachers and also the figures broken down by gender from 1960 to 2000. We are concerned here with factors that prompt teachers to join the pool of potential teachers and also those that induce them to seek work in the non-teaching sector. Moreover, we choose to model the determinants of the change in the pool of inactive teachers, since we seek to examine the flows of this variable, rather than its stock.

Figure 3: Changes in the Pool of Inactive teachers in the UK, 1960-2000



Initial teacher training (ITT) in the UK involves studies undertaken at either the undergraduate or postgraduate level. If this training is undertaken at the undergraduate level, graduates are usually conferred a Bachelor of Education degree, while if it is undertaken at the postgraduate level, the ITT leads to a Postgraduate Certification in Education (PGCE).[4] Figure 4 shows the proportion of male graduates entering ITT by faculty, Figure 5 depicts the proportion of female graduates entering ITT by faculty with Figure 6 providing comparable information at the overall level. This data was compiled from the annual publication on the First Destination of University Graduates.[5]

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[4] For a full description of entry requirements into teaching, see Ross and Hutchings (2003).

[5] This annual publication is available from 1962 and over the years, changes have occurred to the issuing body and also to the title of this publication. Also, in 1995, Post-1992 university statistics were included into the first destination statistics. This accounts for an increase in the number of graduates entering ITT from the different faculties. For further details, please refer to the data appendix which details information on this publication.

Figure 4: Proportion of male graduates entering ITT by faculty, 1962-2001

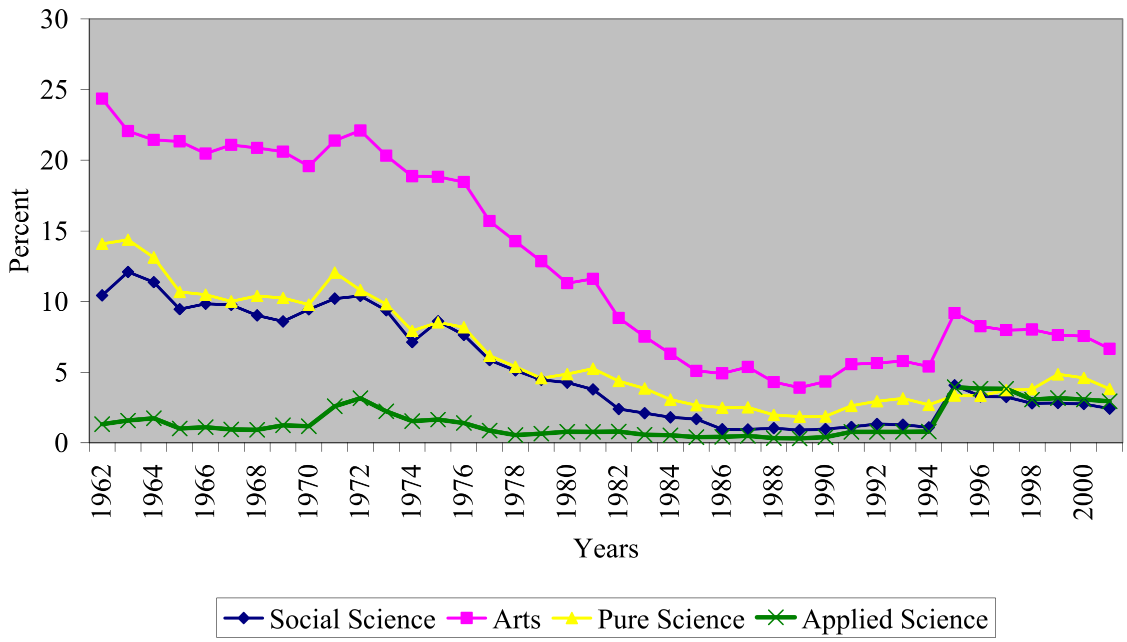


Figure 5: Proportion of female graduates entering ITT by faculty, 1962-2001

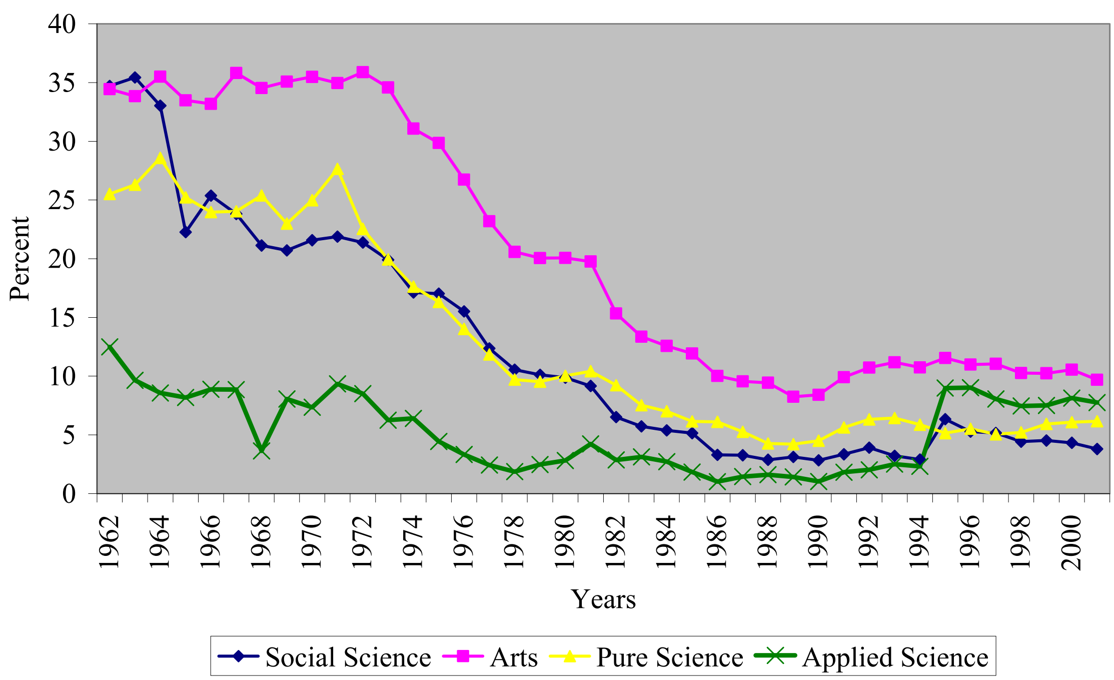
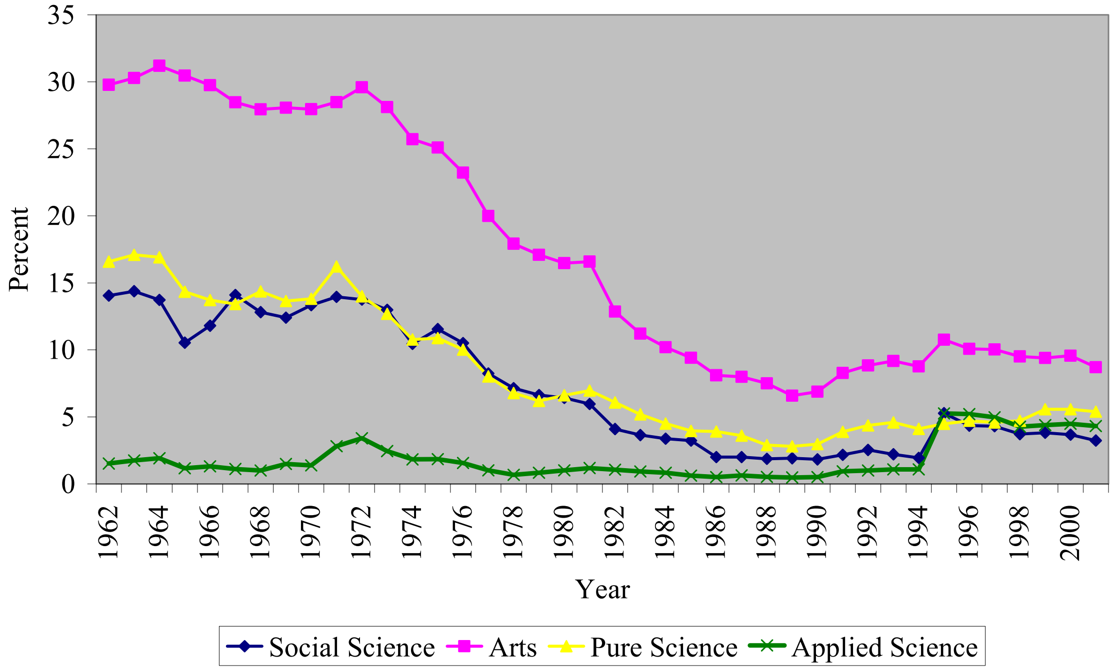


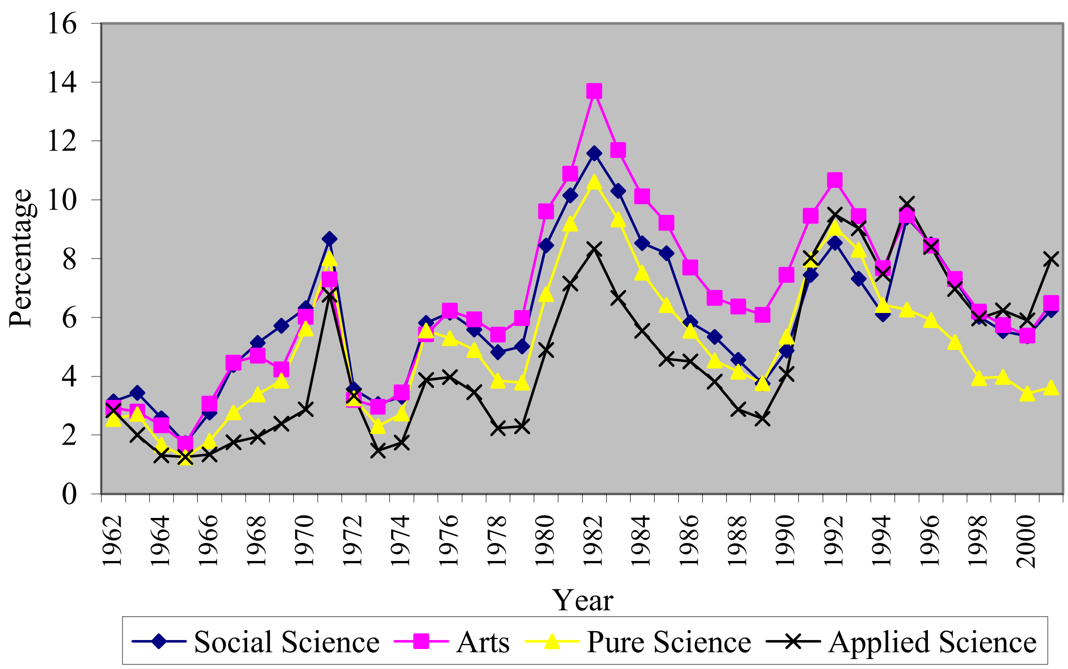
Figure 6: Proportion of total graduates entering ITT by faculty, 1962-2001



The graphs indicate that that a higher proportion of those from Arts faculties enter ITT while Applied Science graduates show the lowest propensity to undertake ITT. Notwithstanding that the number of graduates has increased considerably over the 40 year period (1962-2001), closer investigation of the data, indicates that the growth of those entering ITT is not in proportion to the growth of graduates in all faculties, with the exception of Applied Sciences. In 1962, the first destinations recorded a total number of 4082 Applied Science graduates. The number of applied Science graduates increased to a total of 38015 in 2002 (a growth of more than 800%). Over the same period, the number of Applied Science graduates entering ITT increased from 62 to 1670 graduates. Graduates from the Social Science and Pure Science faculties display the slowest growth in terms of the number of graduates entering ITT as compared to the growth of total graduates from these two faculties.

A non-monetary variable considered in this paper and also used in the previous study by Zabalza (1979), is unemployment among graduates. The rate of unemployment will measure the level of difficulty in securing a job in the labour market. Data collected from the first destination of graduate survey indicates that arts graduates face higher prospects of unemployment. In this paper we take new graduate unemployment to be measured by those who are still seeking employment at the end of their year of graduation. Figure 7 shows the state of new graduate unemployment over time, broken down by faculty. The trend of graduate unemployment among male and female graduates follows the general trend shown.

Figure 7: Total graduate unemployment rate by faculty, 1962-2001

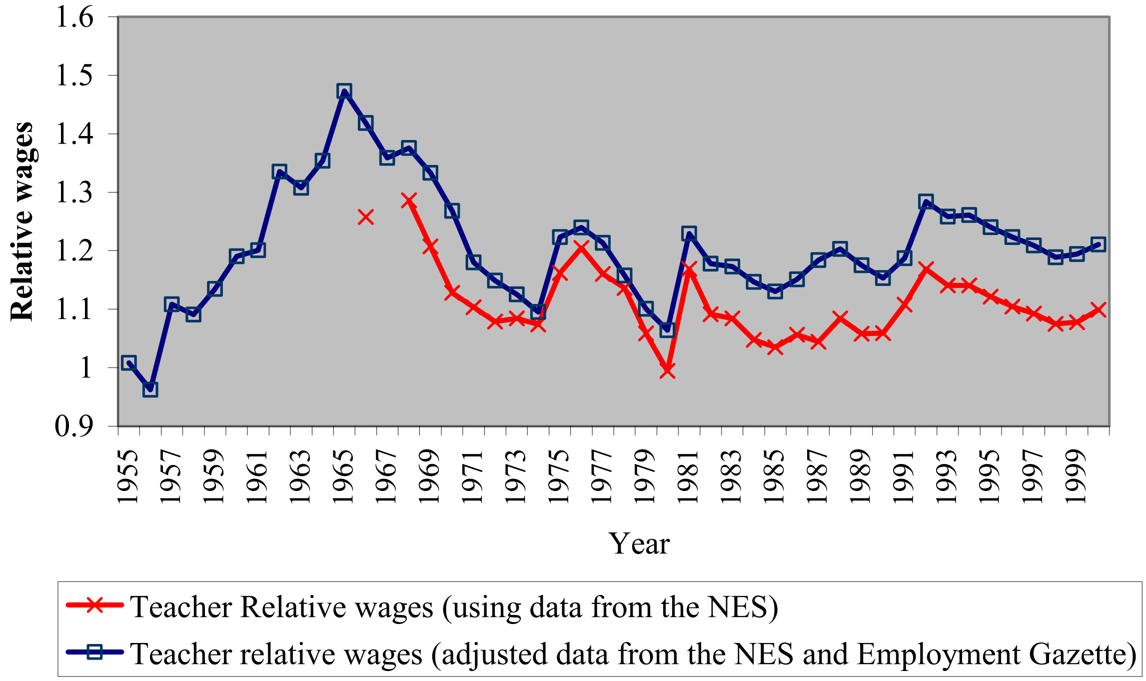


The references given at the beginning of Section 2 indicate that relative wages play a significant role in influencing the decision to become a teacher. Figure 8 graphs the relative earnings of teachers compared to average non-manual earnings and national average earnings.[6] The highest relative wages were paid to teachers in the mid-1960s, followed by a considerable deterioration in the period up to 1973. There followed a

[6] Data on earnings are available from two sources: the October survey of earnings; and, since 1968, the New Earnings Survey (NES). With respect to average earnings of all employees, the two surveys give similar estimates over the period that they are both in existence, and so the reported average earnings is a simple average of the two estimates. For specifically non-manual earnings, the DfES's *Labour Market Trends* (formerly the *Employment Gazette*) reports an index based upon the October survey until 1970, and from then onwards, the NES. However, the resulting estimate is considerably above the estimate of non-manual earnings supplied by the NES, and so in Figure 8, we only display teachers' earnings relative to the non-manual average from 1968 onwards using the NES.

series of dramatic adjustments after the Houghton Report (1974) and the Clegg Commission (1980). More recently, the 1990s have broadly seen a general decline in the relative wage of teachers, although of less dramatic extent than the decline of the late 1960s and early 1970s.[7]

Figure 8: UK Teacher Relative wages, 1955-2000



In addition to investigating the influence of the real average wage effect on teacher supply, real starting salaries were also considered by Zabalza (1979). We were able to collect the starting salaries from different university careers services that had gathered the information via their annual first destination of new graduates' surveys.[8] Data was available for the time period 1960 to 2002 as the various careers services were in the process of collating information from the 2002 cohort of graduates at the time we were collecting our data. Figure 9 displays the real starting salary (at 2002 prices) paid to graduates by faculty. To indicate the relative position of graduates entering the teaching profession, teachers' real starting salary is included in Figure 9. It can be seen that the

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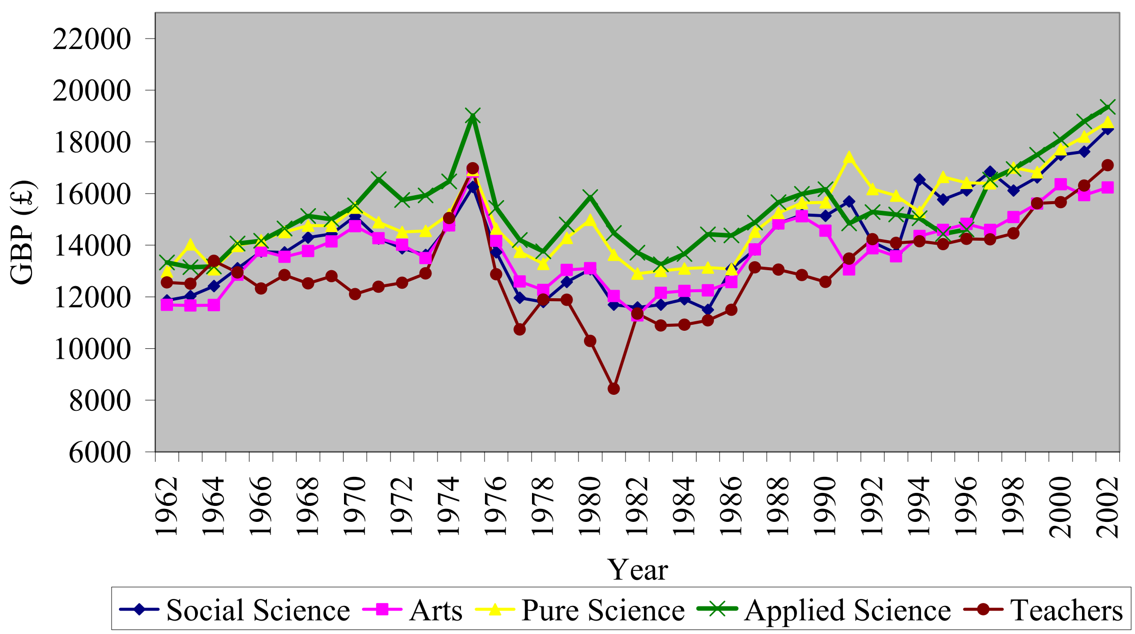
[7] The level of relative wages for females is higher than that for males, with both reflecting the overall relative wages trend.
[8] See data appendix for details.

real starting salary for teachers is lower than that for other graduates from all faculties for substantial sub-periods of the time for which data is available.

Looking at the trend of the real starting salaries for both the teaching and non-teaching labour market, the starting salary for teachers fleetingly matched that in the non-teaching labour market (excepting Applied Science graduates) at the time of the Houghton Report (1974). However, the figure shows that this was not sustained and the pay of starting teachers fell below that offered to graduates who opted for the non-teaching labour market path. The other hike in teachers' starting salary occurred as a result of the Clegg Commission (1980). However, the adjustment to pay was not enough to match the level of starting salary that was paid to graduates outside the teaching labour market.

Figure 9: Real Starting Salary paid to graduates by faculty and to graduate teachers, 1962-2002



4. Modelling time series data to examine the Determinants of Teacher Supply

4.1 Investigating the integration properties of single series.

The application of unit root tests to determine the presence of a stochastic trend in a single time series is now common, particularly in macro econometrics. A frequently used test is the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979).

$$\Delta Y_t = \alpha + \gamma Y_{t-1} + \sum_{j=1}^{p} \beta_j \Delta Y_{t-j} + \varepsilon_t \tag{1}$$

The hypothesis to be tested is that $\gamma = 0$, i.e. that a unit root is present in the data. The null is rejected in favour of a stationary alternative ($\gamma < 0$) for sufficiently large negative values of the test statistic. We set the null and alternative hypotheses in this way because it is standard empirical practice, though we adopted a different approach in testing for unit roots in panel data, as will be seen below. Equation (1) can be augmented to include a deterministic linear trend (t) (indicating a quadratic trend in the data in levels) to give equation (2).

$$\Delta Y_t = \alpha + \gamma Y_{t-1} + \sum_{j=1}^{p} \beta_j \Delta Y_{t-j} + \mu t + \varepsilon_t \tag{2}$$

The presence of deterministic components in any specification being used to test for unit roots has non-trivial implications. For instance, a specification being used to test for a unit root via the ADF procedure where a drift component is specified leads to a different applicable asymptotic theory dependent on whether the drift parameter is zero in truth (although it is fitted) or not. In the first case, the relevant tables based upon limiting Wiener process theory should be used, but in the latter the standard normal distribution should be used.

In testing the female wastage rate data for a unit root, we find an ADF equation with two augmentation lags to be sufficient to leave no evidence of autocorrelation in the residuals of the test regression. The constant term or drift parameter has a prob-value of around

0.11. If we take this to be important in the fitted regression, the prob-value for a one-sided test of the hypothesis that the true coefficient is zero is 0.049. In this case, there does not appear to be a decisive inference, but by assessing this limited evidence that we have in conjunction with other informal checks, such as a plot of the autocorrelation function of the data and Figure 2, we believe, on balance, that this variable should be treated as stationary.

In the case of the male wastage rate, a similar picture emerges with a fitted deterministic trend involved. The constant and trend now both have a prob-value in the region of 0.12 and the test variable for the unit root one of 0.02, conditional on the deterministic component being taken as non-zero. Again, our inclination is to treat this variable as stationary around a deterministic trend after assessing the plots of the autocorrelation function of the data.

A similar ADF test is carried out on the pool of inactive teacher by gender variables. We find that the coefficient on our lagged PITM variable is small and we are not able to reject the null hypothesis of the presence of unit root in the PITM time series. A similar situation is detected in the ADF regression results for the Pool of Inactive female Teachers (PITF) time series data.

While we are able to argue that we may treat the wastage rate variable for females and males as stationary, this is not the case for PITM and PITF. These two variables display non-stationary, I(1), properties. Since we wish to use PITM and PITF as explanatory variables and consider the effects on teacher supply of changes in them, possibly reflecting phases of the economic cycle, we are naturally led to use ΔPITM and ΔPITF in our modelling exercise. We examined the correlogram of the differenced data and find that it showed no evidence of further stochastic trend behaviour. Using the same approach, we tested the other explanatory variables of interest[9] and found that they can be taken to be stationary without differencing.

4.2 Unit root tests for time series cross section data

In the last decade, the testing of unit roots has extended to include panel and time series cross section (TSCS) data. Many of the published studies assume that the data series in the panel are not cross correlated and, when observing a calculated test statistic that indicates at least one unit root across the panel units, it is generally not straightforward to identify which series in the data are stationary and which are non-stationary. This problem will not arise if the null hypothesis is structured in such a way that an insignificant test statistic confirms the presence of no stochastic trend in the time series for any cross section unit. The whole area of panel unit root testing is a current topic of research interest in the theoretical literature, but we feel it is important to consider such tests since we have a rich new data set providing information about ITT across four faculty groupings.

In a recent paper, Harris, Leybourne and McCabe (2003) (henceforth HLM) present a test for panel unit roots which allows for arbitrary cross-sectional dependence and we opted to use this test. This is the first time, to our knowledge, that the test has been used in an empirical paper. It is based upon the null hypothesis that in a set of *N* panel units there are no unit roots and a brief account of the procedure is now given. Suppose for simplicity that

$$y_{it} = \phi_i y_{i,t-1} + \varepsilon_{it} \tag{3}$$

$$i = 1, 2, \ldots N \ , \ t = 1,2, \ldots T$$

The HLM test aims to test the null hypothesis of joint stationarity $(\phi_i < 1)$ for all i = *1,2,…N* against the alternative hypothesis $(\phi_i = 1)$ for at least one *i*. The HLM test allows for arbitrary cross-sectional and serial cross dependence between series in the panel. In

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[9] Namely graduate unemployment (by gender), relative wages (by gender), real GDP growth, trade union density and the proportion of school leavers with 2 or more A-level passes lagged two periods and the female fertility rate.

practice, it will usually be the case that deterministic components like a linear trend and/or a constant will also be fitted. As with unit root tests for single series, such deterministic components have an appreciable effect on the behaviour of the test, both in terms of its asymptotic behaviour and its performance in finite samples.

The test is simple to use in that its asymptotic distribution is standard normal. In order to better approximate this limiting distribution in finite samples, it is necessary to adjust the test statistic with long run variance estimators to remove the effects of temporal dependence in the individual series and also with bias correction factors (which help to attenuate the effects of deterministic nuisance parameters).

The test statistics in the HLM test is built up as follows. Let

$$S_k^* = \sum_{i=1}^{N} C_{i,k}^* \tag{4}$$

where

$$C_{i,k}^* = T^{-1/2} \sum_{t=k+1}^{T} \tilde{e}_{it}\tilde{e}_{i,t-k} + T^{-1/2}[\hat{\omega}\{\tilde{e}_{it}\}^2 + \hat{\psi}\{\tilde{e}_{it}(x_{2,it} - \bar{x}_{2,i})\}^2]. \tag{5}$$

In these expressions $x_{2,it} = t$ is a deterministic linear trend, $\tilde{e}_{it} = \hat{e}_{it} / \hat{\gamma}_0\{\hat{e}_{it}\}^{1/2}, \hat{e}_{it}$ being the OLS residual from demeaning and detrending the individual series in the panel and $\hat{\gamma}_0\{\hat{e}_{it}\} = T^{-1}\sum_{t=1}^{T} \hat{e}_{it}{}^2$. The terms in square brackets are the adjustments referred to above. The lag k is a user-chosen parameter and, following the recommendation of HLM, is set to $k = (3T)^{1/2}$. Terms of the form $\hat{\omega}\{\cdot\}^2$ are estimated long run variance quantities. To compute these requires a further user-defined parameter, called l by HLM, which controls the kernel used in calculating the relevant quantities. We set it to 9 by virtue of T being about 40, thus according with HLM's recommendation. Under the null of no unit roots across the panel, $\hat{S} = \hat{\omega}\{a_t\}^{-1} S_k^* \Rightarrow N(0,1)$ (where $a_t = \sum_{i=1}^{N} \tilde{e}_{it}\tilde{e}_{i,t-k}$)_ and, under the alternative, $\hat{S}$ diverges to $+\infty$. In panel data sets, small sample sizes in the time dimension can be expected to impinge on the reliability and interpretation of the calculated test statistics, just as they do with unit root tests for a single series.

We tested our set of data consisting of information on 4 faculties over the 40 year period using the HLM panel unit root test described above. Table 1 shows the calculated test statistic ($\hat{S}$) for each variable in the panels that we have, viz., the initial teacher training (ITT) variable, graduate unemployment (UG) and the relative starting wages (RSW) variable.[10]

Table 1: Test statistics using the HLM panel unit root test

Variable	$\hat{S}$
Total	
Initial Teacher training (ITT)	0.0499
Graduate unemployment (UG)	1.8421
Relative Starting Wages (RSW)	1.6090
Males	
Initial Teacher training (ITTM)	0.1504
Graduate unemployment (UGM)	1.7660
Females	
Initial Teacher training (ITTF)	0.3409
Graduate unemployment (UGF)	1.7717

From Table 1, there is no evidence of unit roots in the panel for ITT, ITTF, ITTM and RSW. However, the test statistics for UG appear to indicate values just above the 5% critical value of 1.645, so pointing possibly towards some weak evidence of the presence of at least one unit root in the panel for this variable for both sexes and in total. The prob-values for the three test statistics are between 0.03 and 0.05, so the evidence is by no means strong. In view of the possible unreliability of the asymptotic theory as a guide to

[10] The ITT and UG variables are the only panel variables that are available by gender; RSW is at the overall level.

the true, but unknown, finite sample distribution of the test statistics (sample data only spans some 40 years) we opted to maintain that, in the absence of decisive evidence, the panels should be treated as stationary.

5. Estimation Results.

5.1 Models for single time series

Following from the unit root test results, we model the series being treated singly using autoregressive distributed lag (ADL) models fitted by ordinary least squares (OLS). The regressions are conducted separately by gender. We determined suitable lag structures by starting off with more general specifications and omitting lagged variables with insignificant coefficients to arrive at preferred specifications. The use of lagged values of independent variables is motivated by the likely presence of delays in decision making by teachers that economic theory provides little, if any, guidance on. For example, in examining the impact of fertility rates on female teacher wastage rates, we use fertility lagged one period. This is to take into consideration that some females take the decision to leave a teaching job after childbirth. Equations (6) and (7) give the ADL models for male wastage and female wastage rates respectively.

For male wastage rates we use

$$\begin{aligned} WM_t &= \alpha + \delta t + \beta_1 WM_{t-1} + \beta_2 UGM_t + \beta_3 RWM_t + \beta_4 RWM_{t-1} + \\ &\beta_5 RWM_{t-2} + \beta_6 RGDP_t + \beta_7 TUD_t + \beta_8 Q2AM_{t-2} + \varepsilon_t, \end{aligned} \tag{6}$$

where WM_t is the male wastage rate in period t, t the trend term, UGM_t is the male graduate unemployment rate in period t, RWM_t is male relative wages in period t, $RGDP_t$ is real GDP growth in period t, TUD_t is trade union density in period t and $Q2AM_{t-2}$ is the proportion of male school leavers with 2 or more A-level passes in period *(t-2).*

The model used for female wastage rates is

$$WF_t = \alpha + \beta_1 WF_{t-1} + \beta_2 UGF_t + \beta_3 RWF_t + \beta_4 RWF_{t-1} + \beta_5 RWF_{t-2} + \beta_6 RGDP_t + \beta_7 TUD_t + \beta_8 Q2AF_{t-2} + \beta_9 FER_{t-1} + \varepsilon_t, \quad (7)$$

where WF_t is the female wastage rate in period t, UGF_t is the female graduate unemployment rate in period t, RWF_t is female relative wages in period t, $Q2AF_{t-2}$ is the proportion of female school leavers with 2 or more A-level passes in period *(t-2)* and FER_{t-1} is the female fertility rate in period *(t-1)*.

The changes in the male and female pools of inactive teachers are modelled as given in equations (8) and (9). The specification used for males is given by (8) and that for females by (9).

$$\Delta PITM_t = \alpha + \delta t + \beta_1 \Delta PITM_{t-1} + \beta_2 UGM_t + \beta_3 RWM_t + \beta_4 RGDP_t + \beta_5 TUD_t + \beta_6 Q2AM_{t-2} + \varepsilon_t, \quad (8)$$

where $\Delta PITM_t$ is the change in the male pool of inactive teachers in period t, t the trend term, $\Delta PITM_{t-1}$ is the change in the male pool of inactive teachers in period *(t-1)*, UGM_t is the male graduate unemployment in period t, RWM_t is male relative wages in period t, $RGDP_t$ is the real GDP growth in period t, TUD_t is trade union density in period t and $Q2AM_{t-2}$ is the proportion of male school leavers with 2 or more A-level passes in period *(t-2)*.

$$\Delta PITF_t = \alpha + \delta t + \beta_1 \Delta PITF_{t-1} + \beta_2 UGF_t + \beta_3 RWF_t + \beta_4 RGDP_t + \beta_5 TUD_t + \beta_6 Q2AF_{t-2} + \beta_7 FER_{t-1} + \varepsilon_t, \quad (9)$$

where $\Delta PITF_t$ is the change in the female pool of inactive teachers in period t, t the trend term, $\Delta PITF_{t-1}$ is the change in the female pool of inactive teachers in period *(t-1)*, UGF_t is the female graduate unemployment in period t, RWF_t is the female relative wages in period t, $RGDP_t$ is the real GDP growth in period t, TUD_t is trade union density in period t and $Q2AF_{t-2}$ is the proportion of female school leavers with 2 or more A-level passes in period *(t-2)* and FER_{t-1} is the female fertility rate in period *(t-1)*.

Tables 2 and 3 provide the results from fitting (ADL) models to the single series for each gender. The regression results include the variables of principal interest and also the trade union density and the proportion of school leavers with 2 or more A-level passes (lagged two periods) variables. The regression for males in Table 2 shows that the signs of the coefficients are as expected. The coefficient on male graduate unemployment is negative and significant at the 1% level. Similarly, the male relative wages variable is negative and significant at the 1% level. Real GDP growth has a significant negative coefficient at the 10% level and the proportion of school leavers with 2 or more A-level passes is positive and highly significant.

Moving to the results for female wastage rates, fewer variables are found to be significant and the linear trend is omitted because it has almost no influence on the results for the other variables in the specification. The only variables that have significant coefficients in the female regression are: the female graduate unemployment variable; the lagged dependent variable; the trade union density variable; and the lagged proportion of female school leavers with 2 or more A-level passes. The coefficient on female graduate unemployment is of the expected sign while the trade union density variable is highly significant and has a negative coefficient. Similar to the male wastage rate results, the proportion of school leavers with 2 or more A-level passes has a positive and significant coefficient.

Table 3 gives the regression results examining the factors influencing the change in the pool of inactive teachers. Here, we are concerned with looking at the factors that might prompt teachers to enter the pool of potential teachers and to also investigate the factors that might make them leave the pool to seek work in the non-teaching sectors. All variables are significant in the male regressions results displayed in Table 3 except for real GDP growth. Male graduate unemployment and relative wages have a negative and significant coefficient (at the 1% and 5% significance level respectively). Trade union density appears to have a negative and significant effect on the change in the pool of inactive male teachers. The coefficient on the proportion of male school leavers with 2 or more A-levels indicates a positive relationship with the change in the pool of inactive male teachers. The regression results for the female pool of inactive teachers are provided in the right hand column. The relative wages variable has a negative and highly significant coefficient in addition to the lagged dependent variable which is positive and significant at the 5% significance level. The trend variable is also significant and negative indicating a downward trend over time in the change in the pool of female inactive teachers. The other variables did not show any level of importance in influencing the change in the pool of female inactive teachers.

Table 2: Modelling Wastage rates using the Ordinary Least Squares Estimation

Variable	***Male***	***Female***
Constant	-0.0349 (-1.23)	0.0568** (2.38)
Trend	0.0006** (2.22)	
Wastage rate lagged one period	0.5868*** (4.53)	0.3771** (2.20)
Graduate unemployment	-0.0017*** (-4.05)	-0.0011* (-1.86)
Relative wages	-0.0502** (-2.23)	-0.0314 (-1.54)
Relative wages lagged one period	0.0486* (1.78)	-0.0008 (-0.034)
Relative wages lagged two periods	0.0424* (1.77)	0.0380 (1.62)
Real GDP growth	-0.0009* (1.72)	-0.0008 (-1.49)
Trade union density	-0.0042 (-0.520)	-0.0162*** (-2.77)
Proportion of school leavers with 2 or more A-level passes lagged two periods	0.1309*** (3.42)	0.0706** (2.09)
Fertility rate lagged one period		0.0002 (0.784)
No of obs.	38	38
R-squared	0.89	0.78
AR(2) test	F(2,26)=0.45149	F(2,26)=2.3469

Note:
t-statistics are presented in parentheses. * Significant at the 10 % level ** Significant at the 5 % level *** Significant at the 1 % level

Table 3: Modelling the Change in the Pool of Inactive Teachers using Ordinary Least Squares Estimation

Independent variable	*Male*	*Female*
Constant	16860.0*** (6.19)	38818.3** (2.72)
Trend	-72.4607*** (-2.81)	-441.307** (-2.35)
Change in the pool of inactive teachers lagged one period	0.4069*** (4.70)	0.6584*** (4.81)
Graduate unemployment	-185.460*** (-3.94)	-72.8297 (-0.426)
Relative wages	-10453.7*** (-4.53)	-16958.5*** (-3.04)
Real GDP growth	-85.2435 (-1.58)	25.7805 (0.171)
Trade union density	-1212.99** (-1.89)	519.562 (0.197)
Proportion of school leavers with 2 or more A-level passes lagged two periods	19394.6*** (4.66)	15292.8 (1.37)
Fertility rate lagged one period		65.7011 (0.988)
No of obs.	40	38
R-squared	0.88	0.94
AR(2) test	F(2,30) = 0.09928	F(2,27)= 2.0157

Note:
t-statistics are presented in parentheses. * Significant at the 10 % level ** Significant at the 5 % level *** Significant at the 1 % level

Overall, the results from modelling individual time series on teacher wastage rate and the change in the pool of inactive teacher suggest significant relationships between these teacher supply measurements and graduate unemployment. Relative wages appear to be an important factor affecting the teacher labour market, specifically when we distinguish the market for male and female teachers. The results show that males are more sensitive to relative wages than females are (especially in the wastage rate results), a feature which corroborates the cross section evidence that is available.

5.2 Modelling TSCS data

We first fitted individual regressions in the form of autoregressive distributed lag models for each faculty to check for serial correlation. Equation (10) gives the (common) ADL model used.

$$\begin{aligned} LITT\_faculty_t &= \alpha + \delta t + \beta_1 LITT\_faculty_{t-1} + \beta_2 LUNEMP_t + \\ &\beta_3 LRW_{t-1} + \beta_4 TPRTOT_{t-1} + \beta_5 TUD_t + \beta_6 DUMH + \beta_7 DUMC + \varepsilon_t , \end{aligned} \tag{10}$$

where $LITT\_faculty_t$ is the log of the proportion of graduates entering ITT from each individual faculty, i.e. Social Science, Arts, Pure Science and Applied Science in period t, t is the trend variable, $LUNEMP_t$ is the log of the rate of graduate unemployment, LRW_{t-1} is the log of relative wages in period $(t-1)$, $TPRTOT_{t-1}$ is the teacher-pupil ratio in period $(t-1)$ and TUD_t is as given. The inclusion of the teacher-pupil ratio lagged one period is to proxy teacher demand conditions in the UK. This variable provides a way of conditioning on the labour market demand situation. It also indicates the state of teacher vacancies or the saturation of the teaching labour market.

The regressions also include separate dummies to represent two adjustments made to teacher salaries. The first refers to the Houghton Report on teachers' pay in 1974 represented by *DUMH* and the second to the Clegg Report (*DUMC*) in 1980. The dummy variables are non-zero in each case for the year after the two individual reports were published to allow for the effect of recommendations of each commission to impinge on teachers' wages. A trend variable is included into all the regressions since the panel unit root tests were conducted based on including both a constant and a deterministic trend in the specification and to also account for the trends detected in some of the series of data that are used.

The residuals from each individual faculty regression showed no evidence of autocorrelation. This was assessed using a Lagrange Multiplier test for AR(2) errors, employed in its *F-test* variant. The TSCS data is then modelled according to equation (11). The regression using equation (11) is estimated at the total level and also separately by gender.

$$LITT_{it} = \alpha + \delta t + \beta_1 LITT_{i,t-1} + \beta_2 LRW_t + \beta_3 LUNEMP_{it} + \beta_4 TPRTOT_{t-1} + \beta_5 TUD_t + \beta_6 DUMH + \beta_7 DUMC + \beta_8 DSS + \beta_9 DA + \beta_{10} DPS + \beta_{11} DAS + \varepsilon_{it}, \quad (11)$$

where i =1,...,4 and t = 1,…,40 for the period 1962-2001. $LITT_{it}$ is the log of the proportion of graduates entering ITT from faculty i in period t, t is the trend variable and $LUNEMP_{it}$ is the associated log of the rate of graduate unemployment. The graduate unemployment rate is gender specific when the regressions are estimated for males and females. LRW_{t-1} is the log of relative wages in period *(t-1)* while $TPRTOT_{t-1}$ is the teacher-pupil ratio in period *(t-1)*.

We include a dummy variable for each individual faculty, i.e. Social Science (DSS), Arts (Darts), Pure Science (DPS) and Applied Science (DAS) into the regressions to allow for heterogeneity via fixed effects in the model. An *F-test* was conducted to determine the validity of the restricted and unrestricted regressions. We are able to reject the null hypothesis H_0: $\beta_8 = \beta_9 = \beta_{10} = 0$ using an *F-test* for the regression specifications for the male and female regressions at the 1% significance level and more or less at that significance level for regressions using the total value[11]. Hence, the results reported here are regression results of the TSCS models with fixed effects heterogeneity. The reference category for the fixed effects dummies is the Applied Science faculty. Equation (11) is estimated using Ordinary Least Squares (OLS) with panel corrected standard errors (Beck, 2001). Table 4 provides the results obtained from the TSCS data set[12].

[11] The F-statistic (F~(3,144) on the null hypothesis) at the 1% significance level is 3.78 and at the 5% level is 2.60. Using the total variable, the calculated F-statistics is 3.76 (Prob-value ≈ 0.01), while for the male regression, the F-statistic is 4.45 (>3.78) and for the female regressions, the F-statistic is 4.09 (>3.78).

[12] We also examined the results which included a dummy variable, dum92=1 for the year 1995 to account for the inclusion of the Post-1992 statistics in the data. The individual regressions at the total level (namely for the Social Science and Arts faculty) were plagued with serial correlation. We were not able to reject the null hypothesis of no serial correlation at the 10% and 5% significance level for the Social Science and Arts faculty at the total level respectively. The TSCS model for males and females produced similar results to the one which we have reported when we included the dum92 variable.

Consider first the leftmost column of results in Table 4. At the total level, the coefficient on the log of relative average wages lagged one period is positive and significant at the 5% significance level, a result that is, perhaps, to be expected. The log of graduate unemployment rates has a positive coefficient that is highly significant. This result suggests that more graduates are inclined to enter ITT when there is higher graduate unemployment in the economy. These results are in accordance with those found using the data on individual time series data on wastage rates and the change in the pool of inactive teachers in Section 5.1.

The teacher-pupil ratio variable has a coefficient that is significant and negative. Now a greater teacher-pupil ratio indicates that the existing stock of active teachers is high relative to pupil numbers and will also imply that the number of unfilled teacher vacancies is likely to be relatively low. This in turn may suggest that the number of unemployed qualified teachers is high. Hence, if we consider a high teacher-pupil ratio as an indication of high fulfilled demand and low existing vacancies, this may act to discourage graduates from choosing teaching as a career. Therefore, a high teacher-pupil ratio could be negatively perceived by potential entrants to the profession as an indication of saturation of the market for teachers. This may discourage graduates from entering ITT for fear of difficulty in securing a teaching position on completion of their training. In some respects, this finding complements the findings of a positive impact of graduate unemployment in the results.

Turning to the regression results by gender, we find that graduate unemployment remains an important factor in attracting graduates to undertake ITT. When there is high graduate unemployment in the economy, graduates are inclined to enter ITT (coefficients are significant at the 5% significance level for females and at the 1% level for males. More generally, the significance of the variables is stronger in the male regressions as compared to the female regressions; see, for example, the results for graduate unemployment and the teacher-pupil ratio. This may reflect the greater importance to male graduates who choose to enter into ITT of being able to secure a position in the teacher labour market on its completion.

Table 4: Modelling the proportion of graduates entering Initial Teacher Training using panel corrected standard error OLS model.

Variables	*Total*	*Female*	*Male*
Constant	0.5266 (0.620)	0.290 (0.180)	1.887** (2.41)
Trend	0.007 (0.670)	0.006 (0.450)	-0.002 (-0.18)
Log of the proportion of initial teacher training lagged one period	0.803*** (14.78)	0.780*** (10.65)	0.755*** (13.21)
Log of relative average wages lagged one period	1.013** (1.950)	0.757 (0.605)	0.442 (0.720)
Log of graduate unemployment rates	0.253*** (4.14)	0.108* (1.860)	0.273*** (3.750)
Teacher-pupil ratio lagged one period	-37.874*** (-2.61)	-26.0314** (0.046)	-41.391*** (-2.40)
Trade Union Density	-0.108 (-0.38)	-0.043 (-0.15)	0.039 (0.120)
Houghton Report dummy	0.112 (0.800)	-0.002 (-0.01)	0.171 (1.00)
Clegg Report dummy	0.059 (0.440)	0.182 (1.490)	0.017 (0.919)
DSS	1.031 (0.760)	0.828 (0.520)	-0.126 (-0.090)
Darts	0.911 (1.00)	0.768 (0.720)	0.165 (0.170)
DPS	0.531 (1.14)	0.441 (0.820)	0.167 (0.340)
No of Obs	156	156	156

Note:
t-statistics are presented in parentheses. * Significant at the 10 % level ** Significant at the 5 % level *** Significant at the 1 % level

6. Conclusion

This paper examines the determinants of teacher supply in the UK over a large proportion of the post war period from 1960-2001 using aggregate time series data. Two data sets were compiled to facilitate the modelling exercise. The first is a set of single time series over the period. We also exploit a set of time series data relating to four faculties of study, i.e. Social Sciences, Arts, Pure Science and Applied Science, thus allowing us to form a time series cross section data set from 1962 to 2001. Teacher supply is variously measured here by: the wastage rate, i.e. the rate of teachers leaving the teaching profession, either temporarily or permanently; the change in the pool of inactive teachers; and the proportion of graduates entering initial teachers training (ITT) programmes. We relied on the first destination of graduate survey to obtain the graduates' first destination (whether or not it be to ITT) and information on relative starting salaries was obtained through careers offices at various universities.

We used regression methods to model the individual series and also the time series cross section data sets. All variables are carefully examined at the outset to establish whether or not they need to be differenced to obtain stationarity. A novel feature of our work is the first empirical application of a newly proposed test for unit roots applicable to the panel data framework. A robust significant result is the influence of graduate unemployment on teacher supply in the UK. This variable is found to have a significant impact in all situations, regardless of the definition of teacher supply used. Considering the data for males and females separately, where possible, the significance of the graduate unemployment effect is stronger for males than for females. The higher the graduate unemployment rate in the economy, the results indicate a decrease in wastage rates, a lower change in the pool of inactive teachers and an increase in the proportion of graduates entering ITT programmes.

From our analysis of the time series cross section data sets, what also appears to be important for prospective teachers is the security of a teaching position on graduating from their ITT programmes (as evident from the teacher-pupil ratio variable which we included to measure the demand for teachers in the market). Similarly, the effect of this variable appears to be stronger in the male regressions as compared to the female ones.

Using the aggregate time series data for the UK that we have compiled and collated as part of this research, our results corroborate the conclusion of recent cross section econometric research that indicates that teacher supply is sensitive to relative wages in the profession and the nature of graduate unemployment conditions in the labour market.

References

Bartholomew, D.J, Forbes, A.F. and McClean, S.I. (1991), *"Statisticaly Techniques for Manpower Planning"*, John Wiley & Sons, Chichester, 2nd Edition.

Bee, M. and Dolton, P. (1990), 'Where do graduates go? The first destinations of university graduates, 1961-87', *Studies in Higher Education*, Vol.15 (3), pp.313-329.

Bee, M. and Dolton, P. (1995), "The Remuneration of School Teachers: Time Series and Cross-Section Evidence," *The Manchester School*, Vol. LXIII (1), pp. 1-22.

Beck, N. (2001), "Time-Series-Cross Section Data: What Have we Learned in the Past Few Years?", *Annual Review of Political Science*, Vol 4, pp. 271-293.

Chevalier, A., Dolton, P and McIntosh, S. (2001), "Recruiting and Retaining Teachers in the UK: An Analysis of Graduate Occupation Choice from the 1960s to the 1990s." Centre for the Economics of Education Discussion Paper Series 21 London.

Dickey, D.A. and Fuller, W.A. (1979), "Distribution of the Estimators for Autoregressive Time Series with a Unit Root", *Journal of the American Statistical Association*, Vol. 74 (366), pp. 427-431.

Dolton, P. (1990), "The Economics of UK Teacher Supply - the Graduates Decision", *Economic Journal*, Vol. 100 (400), pp. 91-104.

Dolton, P.(2003) "Teacher Supply', forthcoming chapter in '*The Handbook of Education Economics*", North Holland, edited by E. Hanushek and F. Welch.

Dolton, P. and Mavromaras (1994), "Intergenerational occupational choice comparisons: the case of teachers in the UK", *Economic Journal*, Vol. 104, pp. 841-863

Dolton, P. and Robson, M. (1996), "Trade Union Concentration and the Determination of Wages: The Case of Teachers in England and Wales," *British Journal of Industrial Relations*, Vol. 34 (4), pp.539-559.

Dolton, P., Tremayne, A.R. and Chung, T-P. (2003), "The economic cycle and teacher supply", OECD, Paris

Dolton, P. and van der Klaauw, W. (1995a), "Leaving Teaching in the UK - a Duration Analysis", *Economic Journal*, Vol.105 (429), pp. 31-444.

Dolton, P. and Van der Klaauw, W. (1995b), "Teaching salaries and teacher retention." in W. a. B. Baumol, W., *Teaching salaries and teacher retention*, MIT Press., Cambridge MA.

Dolton, P. and van der Klaauw, W. (1999), "The turnover of teachers: A competing risks explanation", *Review of Economics and Statistics*, Vol. 81 (3), pp. 543-550

Harris, D., Leybourne, S. and McCabe, B., (2003), "Panel Stationarity Tests with Cross-Sectional Dependence", Economic Working Paper Archive at Washington University.

Im, Kyung So, Hashem Pesaran, M. and Shin Yongcheol (2003), "Testing for Unit Roots in Heterogeneous Panels," *Journal of Econometrics*, Vol. 115, pp. 53-74.

Levin, A. and Lin, C.F., (1992), "Unit Root Test in Panel Data: Asymptotic and Finite Sample Properties", University of California at San Diego, Discussion Paper No. 92-93.

Maddala, G.S. and Wu, Shaowen (1999), "A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test," *Oxford Bulletin of Economics and Statistics,* Special Issue, pp. 631-652.

Ross, A. and Hutchings, M. (2003), OECD country background report for the UK, Report to the OECD, Paris.
Zabalza, A. (1979), “The Determinants of Teacher Supply”, *Review of Economic Studies*, Vol. 46 (1), pp. 131-147
Zabalza, A., Turnbull, P. and Williams, G. (1979), “The Economics of Teacher Supply”, Cambridge University Press, Cambridge, London.

Data Appendix

Pool of Inactive Teachers (PIT)

This variable attempts to measure those who are qualified to teach but are not teaching in a particular year. We have had to make some assumptions using available data to derive this variable. The PIT measurement here is defined as follows:

$$PIT_{(t)} = PIT_{(t-1)} + ITT - NT - RET + W<60$$

Where

ITT are those completing teacher training,

NT are trained teachers who do not enter teaching

RET are those in the PIT who are of retiring age, and

W<60 refer to those who leave teaching who are under the age of 60.

The PIT data is only available for the period 1959 to 2000. To do this, we have assumed that the overall PIT for 1959 consists of those who left teaching and are under 60 (i.e. W<60) in 1959. The PIT for subsequent years is calculated using the formula presented above. Estimates of the retirement rate and rate of entering teaching by new trained teachers were obtained from the House of Commons report. We have assumed a retirement rate of 1.9 % for the years 1959 to 1989. From 1990 onwards, the retirement rate is 2.6 % as reported in a special report by the House of Common's Education and Employment Committee (1997). The rate of new teachers trained entering teaching, immediately after completing their initial teacher training course is estimated at 80 %. In the report, it is noted, *"Of those who gain a qualification, 80 % take up a teaching post either immediately or at some subsequent point"*. The PIT for males (PITM) and females (PITF) can be determined in a similar way. A caveat we have in estimating the male and female pools of inactive teachers is that we are not able to distinguish the retirement rate and rate of entering teaching separately by gender.

Initial Teacher Training Entrants (itt_x)

This variable is the proportion of graduates entering into the initial teacher training upon completion of their first degree. We have four categories of ITT entrants, by faculty. This data was calculated from data extracted from an annual publication by the University Grants Committee under the following titles: First Employment of University Graduates (1961-1970), First Destination of University Graduates (1971-1978), Details of First Destination of University Graduates for 1979-1980 and for the remaining years of 1981-2000, the relevant data can be found in Volume 2 of the University Statistics: First Destinations of University graduates published by the Universities' Statistical Records on behalf of the University Grants Committee and in the last 6 years, the publication of university statistics was taken over by the Higher Education Statistics Agency (HESA). Post-1992 university data were included from 1995 onwards.

The faculties are the social sciences (*itt_ss*), arts (*itt_a*), pure sciences (*itt_ps*) and the applied sciences (*itt_as*). The data is also divided according to gender. The notation *m* denotes males and *f* is used to denote females.

Wastages (W)

This refers to the teacher wastage rate or the rate of those leaving teaching. The wastage data that we utilise are for those below the age of 60. Wastage figures and the number of male and female teachers were obtained from DES/DfES Statistics of Education, Teachers' Volumes.

Teacher Pupil Ratio (tprtot)

The teacher pupil ratio is used to proxy teaching conditions. This variable is calculated by taking teacher supply divided by the number of pupils in school.

Teachers' Relative Starting Salary.

To calculate the teachers' relative starting salary, we used the weighted average starting salaries of graduates by faculty and the teachers' starting salary. The latter data were taken from the Scale of Salaries for teachers in primary and secondary schools: England

and Wales for the years 1960 to 1983. The teachers' starting salary for the years 1984 to 1986 was obtained from the National Union of Teachers while data for the rest of the years, i.e. 1987-2000 were taken from the School Teachers' Pay and Conditions document.

To obtain the relative starting salary, we required a set of information on the starting salary of graduates. The early series of this data (i.e. 1960 to 1986) was provided by Peter Dolton who had collated this information in 1989 (See Bee and Dolton, 1991). In extending this set of data, we sought and obtained the help of various university careers services. The procedure followed was to request for information from as many universities as possible. In the collation of the data, the guiding principle was to use as much of the data as was feasible.

We are grateful to the Careers Officers and/or Directors of each university for making the data available to us. The following universities careers service provided the data which allowed us to construct the weighted average starting salaries by faculties. University of Bristol, University of Birmingham, University of Leeds, University of London, University of Nottingham, University of Plymouth and the University of Salford. The University of Newcastle data was provided by Peter Dolton and was extracted from the Newcastle alumni survey data collected in 1998 which contained information of graduates dating back to the 1950s.

Deflating the nominal wages by the RPI (Jan 1987=100) to obtain the real values, the relative starting salary was calculated by taking the teachers' real starting wages divided by the weighted real average starting salary by faculty (Social Sciences, Arts, Pure Sciences and the Applied Sciences). This variable is not available by gender.

Relative Teacher/Non-teacher Wage (rw)

Data on the teachers' pay was taken from the series of publication by the DES/DfES on teachers (i.e. Statistics of Education: Teachers in England and Wales). For the non-teacher wage, we used the information collated from the New Earnings Survey (Source:

Employment Gazette for the non-manual earnings index for the earlier years, 1959-1967 and Part E of the New Earning Survey publications) for non-manual workers to measure the non-teacher wage. The relative wage measurement is calculated based on the real wages (January 1987=100) of teachers and non-manual workers. Relative wages are also measured separately for the males and females.

An alternative relative teacher/non-teacher wage was calculated using earnings data extracted from the NES. The earnings of the professional occupations were used to measure the non-teaching sector's average wages and sub-categorised into faculties. For example, a lawyer would be categorised under the social science category while an engineer or architect or town planner would come under the applied science category. To standardise the measurement of the relative wages, we extracted the teacher earnings (i.e. secondary and primary teachers) from the NES to be used as the numerator in the calculation of the alternative relative teacher/non-teacher wages.

Graduate Unemployment Rates (u_x)

This variable is also compiled by faculty and is extracted from the annual publication by the University Grants Committee under the following titles: First Employment of University Graduates (1961-1970), First Destination of University Graduates (1971-1978), Details of First Destination of University Graduates for 1979-1980 and for the remaining years of 1981- 2000, the relevant data can be found in Volume 2 of the University Statistics: First Destinations of University graduates published by the Universities' Statistical Records on behalf of the University Grants Committee and in the last 6 years, the publication of university statistics was taken over by the Higher Education Statistics Agency (HESA). We calculated the proportion of graduates who were considered unemployed at the time of the survey. We used the notations *ss*, *a, ps* and *as* to represent the four faculties of Social Sciences, Arts, Pure Sciences and the Applied Sciences. Post-1992 university data were included in the first destination count from 1995 onwards. It was not possible to extract these universities out from the original Pre-1992 universities.

Proportion of School Leavers with 2 A-levels (q2a)

School leavers with 2 or more A-levels can be obtained from various sources - mainly from the Statistics of Education: Volume 2 on School leavers GCE and CSE. When this volume on school leavers ceased publication, the data was then extracted from the Statistics of Education, UK compiled by DES. Data for 1954 to 1961 was taken from the Robbins report (appendix 1, page 112). For the later years (1996-2000), the data was taken from the DfES' GCSE/GNVQ and GCE A/AS/VCE/Advanced GNVQ Examination Results. The proportions are then measured by taking the number of school leavers with 2 or more A-levels divided by the total number of school leavers. A caveat to note here is that the school leaver population ceased to be reported from 1991 onwards and for the missing years, the percentage of those with 2 or more A-level passes were based on the total population aged 17.

Teacher Union Density (tud)

The teacher trade union data series was taken from Dolton and Robson (1996) and was extended to the year 2000. The data for the later years (1993-2000) was collected from the Certification Office for Trade Unions and Employers' Association. Unions included are: The National Association of Schoolmasters and Union of Women Teachers (NASUWT), National Association of Head Teachers (NAHT), Association of Teachers and Lecturers (ALT), Secondary Heads Association (SHA), Professional Association of Teachers (PAT) and the National Union of Teachers (NUT). Union mergers over time are captured in the data.

The teacher trade union membership concentration is defined as:

$$\text{tud} = \frac{\text{Union Membership}_t}{\text{Teachers}_t}$$

Dummy variables

dumH and *dumC* – Dummy variables for the years of the Houghton Report on teachers' pay in 1974 and the Clegg Report in 1980, lagged one period for the effect to be felt on wages.