The Economic Cycle and Teacher Supply

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Introductory Note

This paper was prepared in support of the OECD Education Committee's Activity *Attracting, Developing and Retaining Effective Teachers* in its 2002-2004 Programme of Work. It was commissioned by the Education and Training Policy Division in the Directorate for Education and it complements the analyses being undertaken by the participating countries and the OECD Secretariat.

The overall objective of the *Attracting, Developing and Retaining Effective Teachers* Activity is to provide policy makers with information and analysis to assist them in formulating and implementing teacher policies leading to quality teaching and learning at the school level. The activity is intended to: (i) synthesise research on issues related to policies concerned with attracting, recruiting, retaining and developing effective teachers; (ii) identify innovative and successful policy initiatives and practices; (iii) facilitate exchanges of lessons and experiences among countries; and (iv) identify policy options. The final synthesis report is to be published in 2004. Detailed information about the activity is provided in the following internet site: www.oecd.org/edu/teacherpolicy

Executive Summary

This paper examines how the economic cycle affects the market for teachers. It begins by defining and measuring the business cycle in the UK. Following the identification of the business cycle in the UK, we present a simple model of the teacher labour market. We also look at how, theoretically, the supply of teachers could be affected by the economic cycle to enable us to set out a clear model of the way the teacher labour market functions. In addition, the different concepts and measurement of teacher supply and teacher shortage are explored in this paper. We then review the literature examining the influence of macroeconomic indicators on the supply of teachers and other qualified workers both in the UK and USA. From this review, it is evident that this literature is fairly small and relatively inconclusive. Cross section evidence suggests that relative wages in teaching compared to alternative professions have a significant impact on the likelihood of graduates choosing to teach, although the impact depends upon the market situation at the time. Time series evidence on teacher supply is limited.

We reappraise this evidence by a careful analysis of UK and USA data (over the 1960-2000 and 1970-2000 periods respectively). The aggregate time series data available for this study are relatively limited but every effort has been made to use all available sources. The main UK data source was Government annual publications on teachers and other general economic indicators while for the USA data was mainly compiled from publications by the National Centre for Educational Statistics (NCES) and also calculated based on a model used by Weaver (1980). We were also able to utilise a set of educational data collected by the OECD and UNESCO with support from the World Bank to examine the relationship between the supply of teachers and economic growth in countries that participated in the World Education Indicator (WEI) project.

We fitted our UK and USA data into an autoregressive distributive lag model, which is a dynamic model that has allowed us to have some empirical understanding of the relationship between teacher supply and the economic cycle in the UK and the USA. Our measure of teacher supply in the econometric modelling included teacher-pupil ratio, attrition rates and the pool of inactive teachers for the UK and the overall teacher-pupil ratio for the USA. In the UK case, we have examined each variable separately by gender.

The real GDP growth variable is not statistically significant in most of our regression results, regardless of the teacher supply measurement that we use for both the males and females. Fertility has a significant effect on the female teacher-pupil ratio in the UK. The higher the fertility, the lower the teacher-pupil ratio variable, indicating that female teachers tend to leave the teaching profession to take up household responsibilities especially after childbearing. When the relationship between real GDP growth and teacher supply is significant, the impact of this relationship is low. This result is identified when using male attrition rate as the measure of teacher supply in the UK. In general, the male regressions indicate more interactions between the dependent variable (i.e. the supply of teacher measured by the different variables) and the independent variables (i.e. real GDP growth, graduate unemployment, relative wages, trade union density and teacher quality) compared to the female regression results.

Our time series evidence also shows that males are more sensitive to relative wages compared to females. Male teacher supply is also responsive to the condition of graduate unemployment in the UK economy. Both the relative wages and graduate unemployment variables are significant in the regression results, especially when using the male attrition rates and changes in the pool of inactive male teachers as measures of the teacher supply in the UK. We also find some evidence that educational quality improvements could have a negative impact on teacher supply. The proxy variable for teacher quality (lagged two periods) is significant and positive in a number of our regressions, namely, in the male and female attrition regressions, in addition to the change in the pool of inactive teachers for males. The positive sign suggests that teachers with better examination results have a higher likelihood of leaving the teaching profession.

The findings for the USA emulates those found by Berman and Pfleeger (1997). In the USA regression, there is no significant variable that we are able to tie in with our measure of teacher supply in the USA, i.e. the overall teacher-pupil ratio. Although relative wages between teachers and other employees working full-time in the USA is significant, the sign that we obtained is counterintuitive. We think that this discrepancy in sign could have been attributed to some level of heterogeneity in the teacher labour market in the USA, in addition to our analysis being confined to a small sample size. Through the usage of the WEI data for 1999, we are able to detect a positive and significant relationship between the change in GDP and the level of teachers' salary.

Overall, our results suggest a significant relationship between the economic cycle and teacher supply when these effects are measured in terms of relative wages and unemployment (but not GDP growth) in gender specific equations. Relative wages appear to remain as an important factor affecting the teacher labour market in the UK, specifically when we distinguish between the market for male and female teachers. Hence, our time series analysis is able to confirm results from research, which uses cross section data analysis on the teacher labour market, both in the UK and the USA.

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1. Introduction

A matter of continuing concern for education policy in OECD countries is the shortage of teachers. More specifically most member countries experience shortages of teachers in certain subjects and geographical areas at certain points in time. It is unclear the extent to which the shortage of teachers in any member country may be related to the aggregate labour market position over time.

This study seeks to examine whether economic cycles impact on the attraction and retention of teachers and if so, in which ways. Analysing these relationships needs to take into account demographic trends and changes as well as other possible intervening factors like related education, governance or industrial reforms that may impact on the labour market for teachers. More specifically, the study will explore in depth the following themes:

- What is the time lag between economic cycles and changes observed in the labour market for teachers? What are the policy implications of these trends (when policies to combat shortages can result in later surpluses)?

- How does the labour market for teachers respond to a strong economy and low unemployment? Is it harder to recruit and retain teachers during those times? If so, does the relationship operate differently for some groups of teachers (subject focus, primary and secondary schools) or teachers with different qualification levels? Which types of teachers leave the profession earlier at times of economic booms? How does their pattern of behaviour differ from those of (i) civil servants or (ii) other professions with similar levels of qualifications?

- At times of crisis and economic downturns, is teaching valued for the safety and stability it offers so that more people are interested to teach and fewer drop out of the profession? What is known about the characteristics of those attracted into teaching in such periods? Does the relationship operate differently for some groups of teachers (subject focus, primary and secondary schools) or teachers with different qualification levels? How does their pattern of behaviour differ from those of (i) civil servants or (ii) other professions with similar levels of qualifications?

The central question in this report is: does the economic cycle affect the supply of teachers, and if so – to what extent? To begin to understand this question we must also explain how the economic cycle could theoretically affect the supply of teachers. There is a limited amount of empirical research on this issue (as will be evident in the literature review section), mainly caused by the difficulty in obtaining and compiling a reliable set of data. However, using available sources of data in the UK and USA, this paper will attempt to apply appropriate techniques to examine the relationship between the individual country's business cycle and teacher supply.

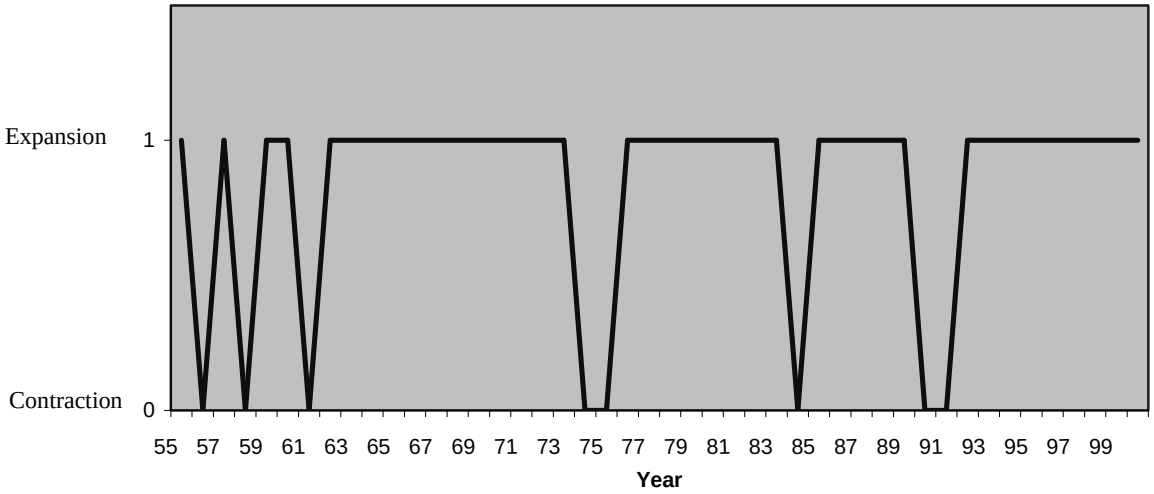
To carry out this task, this paper will firstly attempt to establish the presence of the business cycle in the UK before looking into the theory of why and how the economic cycle might have an impact on the supply of teachers. This latter issue will be examined in Section 2. It is only after this can we consider a simple model of the teacher labour market in Section 3. Section 4 will aim to determine how the supply of teachers is affected by the economic cycle while in Section 5, we will explore the different concepts of teacher supply and teacher shortage. Section 6 will review the literature on teacher supply and other qualified workers to give us a picture of the research findings that are currently available. The empirical evidence for the UK and the USA using graphical descriptions based on the data collected from various sources will be presented in Sections 7 and 8 respectively. In Section 9, we will utilise the data jointly collected by the OECD and UNESCO to examine the relationship between teacher supply and the economic cycle in the other countries of the world, namely those that participated in the World Education Indicator (WEI) project. Section 10 will contain the review of the results using time series techniques in an econometric modelling of the teacher supply and the economic cycle. Our conclusions are presented in Section 11.

2. The Business Cycle and its Potential Influence on Teacher Supply.

Since the work of Burns and Mitchell (1946) macroeconomists have been concerned with assessing the presence of cycles in time series data. These authors set out means for determining the presence of cycles in variables such as GDP that have become established through their use by the NBER committee that dates the business cycle for the United States. The committee uses judgmental criteria, but the work of Bry and Boschan (1971) established a formal algorithm for business cycle determination. The rules inherent in any such algorithm

should be clear, simple and reliable. Using the algorithms of Bry and Boschan, Harding and Pagan, Figure 1 illustrates the business cycle in the UK.[1]

Figure 1 : The Business Cycle in the UK, 1955-2000



There is also a vast literature on the theory of real business cycles (RBC). Theories of the real business cycle attempt to explain the microeconomic foundations of economic fluctuations. Some of the papers in this literature explicitly recognise a role for the labour market in their explanation of economic cycles. These are adequately summarised by Stadler (1994) and Arnold (2002). What we seek to take from these theories is how the nature of aggregate fluctuations in the economy may affect the supply of teachers. The majority of the RBC literature focuses on the theories, which emphasize the role of the labour market in generating persistent cyclical fluctuations in the economy. In contrast, we are keen on examining the effects that the business cycle might have on teacher supply.[2]

Another critique that we have on the RBC model is that the RBC models above are all framed within a single sector for labour. Our concern is with a situation in which there are two sectors in the labour market – the teacher labour market and the non-teacher labour market. Any of the above theories could generate changes in the demand for labour generally and result in upward or downward pressure on market wages in the economy.

[1] Appendix A details the method used to test and measure the presence of the business cycle in the UK.

[2] There are six theories of the RCB, which have explicitly modelled a key role for the labour market in the generation of business cycles. They are the: Basic Neo-Classical Labour market (see King *et al*, 1988), the indivisible labour model, labour hoarding, the Search model, Gali's Imperfect Competition Model and the distortionary taxes model.

The assumption that we apply in our theoretical model is that the non-teacher labour market is the competitive private sector labour market and that all teachers work in the public sector. Based on this assumption, the real relative wage in teaching compared to the private sector alternative is subject to the vagaries of any of the factors, which could generate a RBC. As part of the labour-leisure trade off in the RBC models we could imagine that the choice for each agent is between leisure and labour in the public (teaching) sector or the private (non-teaching sector). The choice of how much labour to supply to one sector or the other is, in practice, limited by indivisibilities such that each agent must choose in a given time period to work in one sector or the other. The agent will do this based on the size of the relative wage in the two sectors and the employment (or unemployment) prospects in the two sectors. This decision can change at each point in time as the relative wage in the two sectors varies.

The formal modelling of the graduate's decision to enter teaching or not has been set out by Zabalza et al (1979), Zabalza (1979) and Dolton (1990). In these models it is possible to show that the decision to enter teaching or not will be a function of the relative wage on offer in the teacher and the non-teaching alternative. The model by Dolton (1990) also suggests that the relative cost of entering one occupation or another in terms of training time and the level of student support may play a role in the decision. Likewise the model can easily be extended to include the possibility that there is the uncertain prospect of work in the non-teaching alternative. In which case it is straightforward to show that the decision to enter teaching will also be a function of the relative likelihood of unemployment in the two alternative careers.

The paper by Dolton (1990) also considers the possibility of changing occupational choice any time after the initial choice after graduation. Here again it is straightforward to show that the decision is a function of relative wages in the two alternative choices as well as the unemployment prospects.

To get an idea of how the labour supply of teachers varies over the economic cycle we must relate teacher supply data to: the nature of the real relative wage in teaching, fluctuations in unemployment and changes in GDP. The naïve search for a relationship between the economic cycle and teacher supply would concentrate on the examination of the relationship between GDP growth and teacher supply. It should be appreciated that any relationship between aggregate fluctuations and teacher supply is most likely to manifest itself in a

relationship between graduate unemployment, relative wages and teacher supply. This is to be expected if relative earnings and employment prospects concretely affect the real occupational decisions of young people contemplating a career in teaching. It is less likely that their decision will be directly affected by the aggregate health of the economy as measured by economic growth.

Indeed, simplistic RBC interpretation assumes that all the cyclical variation in teacher supply is generated by fluctuations in the aggregate economy as driven by changes in the graduate unemployment rate and the real relative wage in teaching. It should be appreciated that any simple consideration of the teacher supply problem shows that there are other exogenous factors, which could influence the supply of teachers. Other conditioning factors must include:

- The rate of government spending on education.
- The level of teacher trade union density. The influence of trade unions is usually associated with wage bargaining (see Dolton and Robson, 1996). The hypothesis is that the greater trade union density or concentration among the teachers, leads to higher wage settlements.[3] Theoretically, we would then expect the supply of teachers to increase, as more teachers are enticed to enter the profession given the higher relative wages due to the higher wage settlement brought about by trade union negotiations.
- Changes in the proportion of young people who could enter teaching in terms of the available supply of educated young people. Changing demographic trends and changes in education standards could have an impact here.
- The level of financial subsidies to young people to study in higher education.
- Changes in regional differential pay payments, for example those available to teachers in London where a disproportion of the vacancies occur.
- Exogenous[4] changes in the fertility of young women. Women are traditionally said to leave the labour market for household production and family responsibility reasons. The higher the fertility rate, the higher the outflow of female teachers.

[3] Other relevant literature on this issue include amongst others, Coates, 1972, Saran, 1985, Booth and Chatterji, 1995 and Ironside and Siefert, 1995.
[4] The change in fertility is considered as an exogenous variable as we refer to it being a variable whose value is not determined within the econometric modelling which we wish to use later on.

We must take into consideration, as far as possible for all of these factors in modelling the supply of teachers and how it varies over the business cycle. However it is not the task of this report to set out a general theory of how these factors interrelate. Our task is primarily an empirical one. We will examine the evidence relating to these variables for the UK and the USA and then investigate the econometric model of their interrelationship.

3. A Simple Model of the Teacher Labour Market.

In the Zabalza *et al* (1979) model of the labour market, the demand for teachers is formulated in terms of the number of children of school age, and the government's own desired pupil-teacher ratio. Clearly, if the government was willing to accept higher class sizes then it could cut the demand for teachers immediately by increasing its desired pupil-teacher ratio. In the current political climate, with numerous pressures on the government to cut class sizes and improve key stage examination performance, this option is unlikely to be adopted. The other factor determining the level of demand for teachers, the number of children who require teaching, is outside government control. It would therefore appear that the most feasible route for reducing the excess demand for teachers is via an increase in their supply. It is thus upon the supply of teachers that this paper focuses.

The supply of teachers can be regarded as all those currently in teaching, plus those currently not teaching, but who are qualified to teach, and would consider teaching if the conditions were right. The supply issues at stake are therefore ones of recruitment and retention, as well as inducing the return of individuals who have left the profession.

There are many factors that are likely to influence the supply of teachers, such as the relative earnings on offer in teaching and other careers, other labour market opportunities, and varying relative non-pecuniary conditions of work. To a certain extent, some of these factors can be controlled by the government, for example, the earnings that teachers receive, and so public policy can have an influence on supply.

Much of the analysis that follows focuses on the earnings that individuals can earn as teachers, relative to what they could earn in alternative occupations, as one of the key determinants of the decision to become a teacher. It is likely that non-pecuniary factors such as workload, job stress, physical surroundings and related factors also play an important role in the decision to enter teaching.

Indeed, anecdotal evidence would suggest that such conditions are adversely perceived by current and potential teachers, which can have a real effect on reducing the supply of labour to teaching (Coulthard and Kyriacou, 2002). Unfortunately, our data sets do not contain measures of such working conditions, and so our focus is on more quantifiable determinants such as levels of remuneration.[5]

We now outline a simple model of the labour market for teachers, illustrating how a situation of excess demand (or insufficient supply) can arise. Following Zabalza *et al* (1979), the labour market for teachers can be thought of within a traditional supply and demand framework, with the additional complication that the government is virtually the sole hirer of labour.[6]

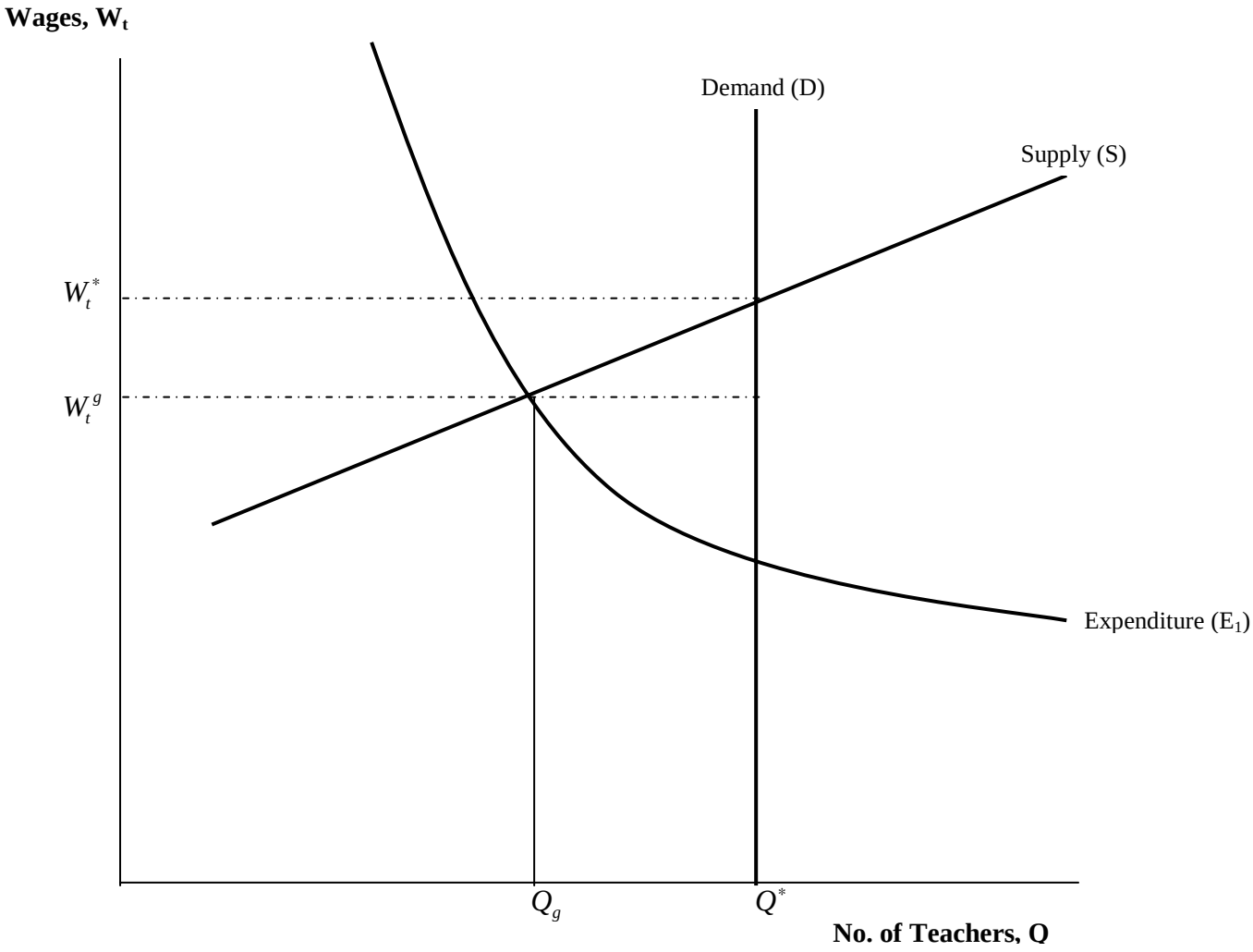
Demand for teachers is determined by the number of children in the country of school age, and the government's desired pupil-teacher ratio. For a given such ratio, the demand for teachers is therefore a constant, denoted by Q^* in Figure 2. Under the reasonable assumption that the supply of teachers is a positive function of average teacher earnings, an upward-sloping labour supply schedule can be drawn as S. In a perfectly competitive market, a wage of W_t^* would therefore clear this labour market. However, the teachers' labour market is of course not perfectly competitive, and the government, in its role as (almost) exclusive purchaser of teaching labour, has other considerations, prime amongst which is the level of expenditure on teachers' salaries in total.

For a given level of such expenditure, an inverse relationship can be plotted between teachers' earnings and the number of teachers hired, labelled E_1 in Figure 2; if the government wants to raise the salaries of teachers, it can afford to hire fewer of them, given a fixed budget. The number of teachers hired is therefore Q_g at average earnings of W_t^g, and the excess demand for teachers is $Q^* - Q_g$. This can only be eradicated by a relaxing of the budget constraint leading to higher earnings, or other factors changing to make teaching more attractive, so that more potential teachers supply their labour at any given wage. This paper examines the supply responses to changes in wages, and other factors.

[5] In a related paper (Chevalier *et al (2001)*, we do consider reported satisfaction with a number of aspects of working life, using data from the 1985 and 1990 Graduate Cohort Data Sets used below. The results suggest that teachers are less satisfied than other graduates concerning key aspects of their jobs, such as pay and hours worked.

[6] The private sector in the UK accounts for no more than 5-7% of all teachers hired.

Figure 2: The Labour Market for Teachers



Of course, the above analysis is simplistic in that it treats all teachers as being the same. In reality, there may be teacher shortages in particular regions or in particular subjects, with an over-supply elsewhere. In addition, the real market position is different for primary and secondary school teachers. The number of primary and secondary school children could vary; hence affecting the number of teachers required in the primary and secondary school sectors. In addition, the specialism required could differ between these two schooling sectors. We can amend Figure 2 to allow for such possibilities by creating a simple distinction of different kinds of teachers. A simple analysis would suggest that the possibility of differential wages by subject, in different regions or between primary and secondary sectors could be adopted to solve the problems of short supply in particular areas. Whether this solution is actually viable, given the demands of teachers' unions and the political process in general, is another question. In any detailed empirical analysis, we would wish to allow for the

possibility that supply responses differ by subject of study amongst potential teachers. However, again due to data limitation, we are not able to consider the background (i.e. subject of study) of potential teachers.

4. How might the Supply of Teachers be affected by the Economic Cycle?

We have argued above that the main mechanism of fluctuations in the economic cycle, which will affect the supply of teachers, is changing relative wages. Under RBC theory any exogenous shock like an increase in the rate of technical progress could shift out the demand for labour function causing rising private sector wages. It is likely that a change in the rate of technical progress will have much more effect in the private sector where there is much more scope for substitution away from labour and into IT and more advanced technological physical capital.[7]

This change is depicted as the shift of demand for private sector labour from D_0 to D_1 in Figure 3a. The resulting raising private sector wages will cause lower (short run) teacher's relative wages and hence a shift of the supply for teachers as fewer people will present themselves for teaching jobs at lower relative wages (See Figure 3b).

[7] It is of course possible that IT can be used in the classroom but relatively speaking, teaching is a labour intensive activity with less scope for substitution, i.e. to use computers to replace teachers.

Figure 3a: Non-Teacher Private Sector Labour Market.

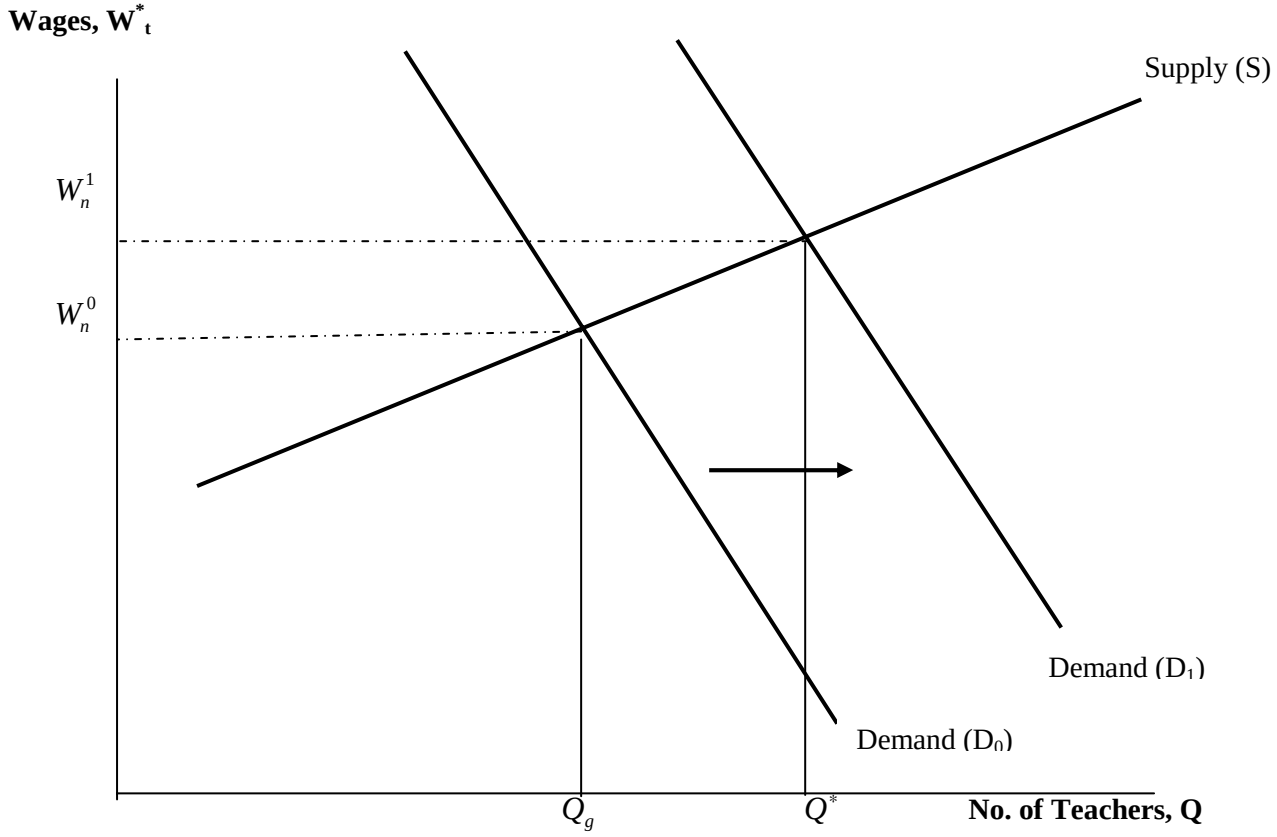
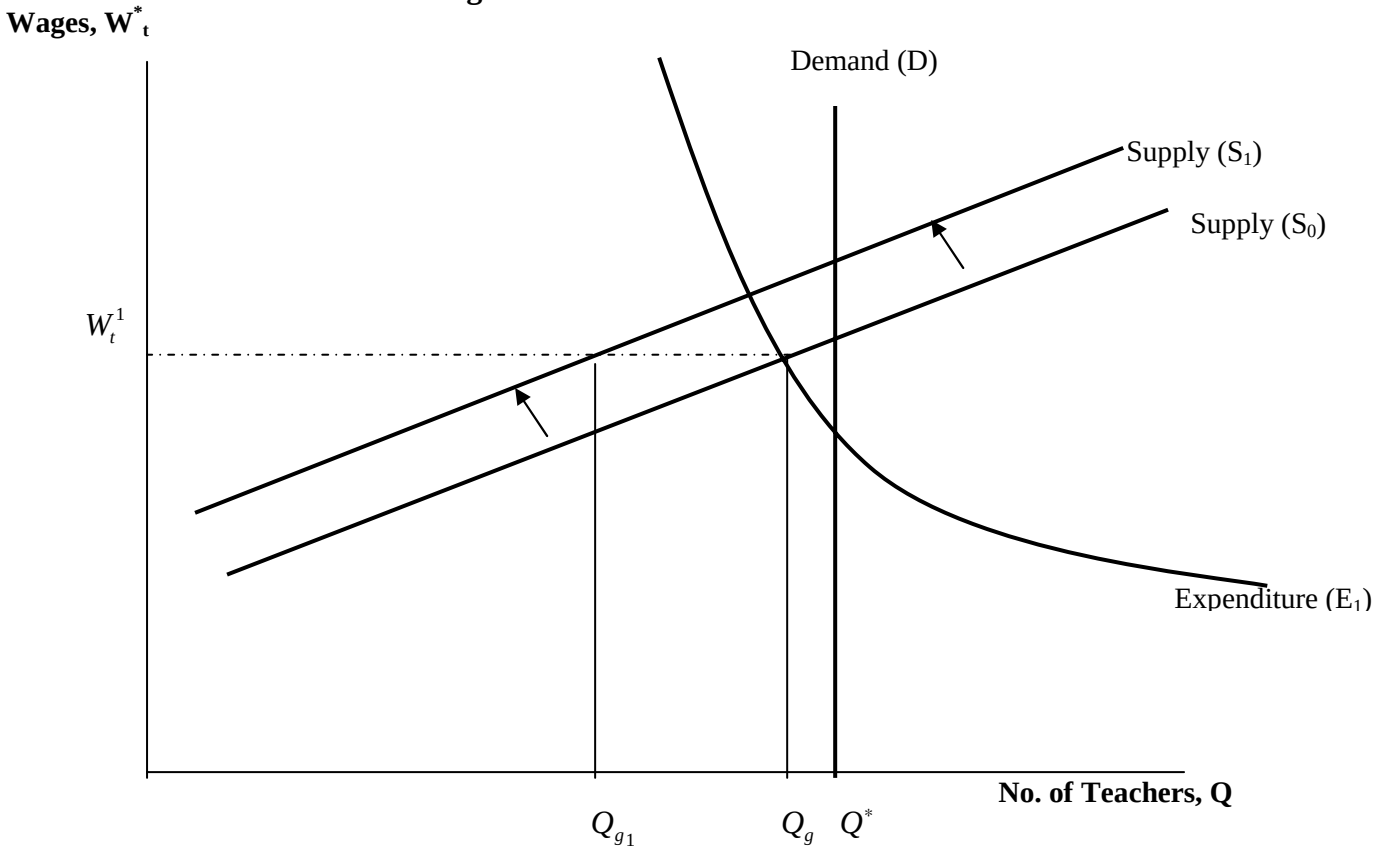


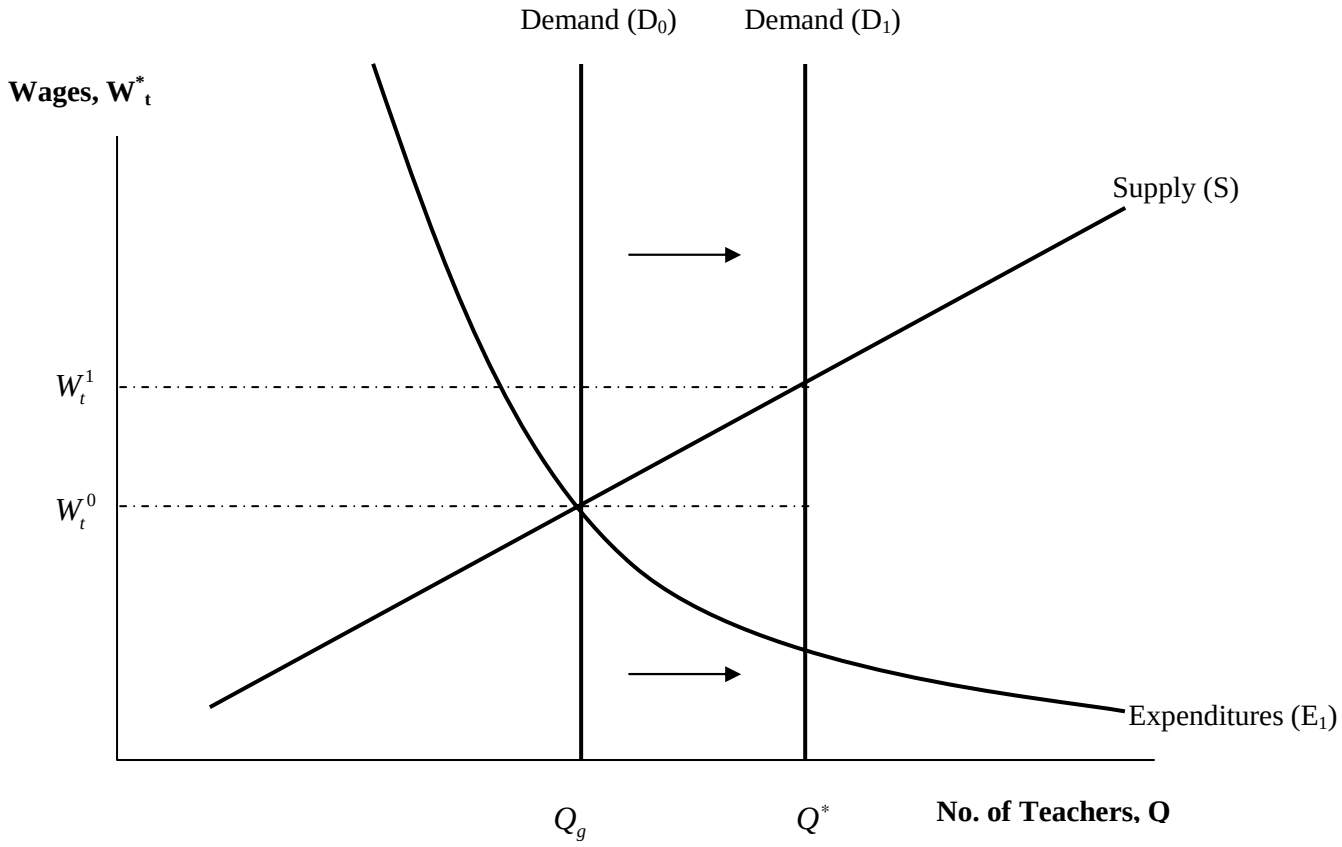
Figure 3b: Teacher Labour Market.



There are many other ways in which the supply of teachers can be altered. Consider the effect of an exogenous change in either the government's target pupil teacher ratios or a demographic shift in the birth rate. Assume that either there is an upward shift of the birth rate or that the government decides to lower pupil-teacher ratios by increasing education spending. Let either of these changes be captured by the shift of the inelastic demand from D_0 to D_1 in Figure 4. If the government is not prepared to raise teacher wages then this will mean that there is a shortfall of $(Q^* - Q_g)$ in the equilibrium number of teachers employed.

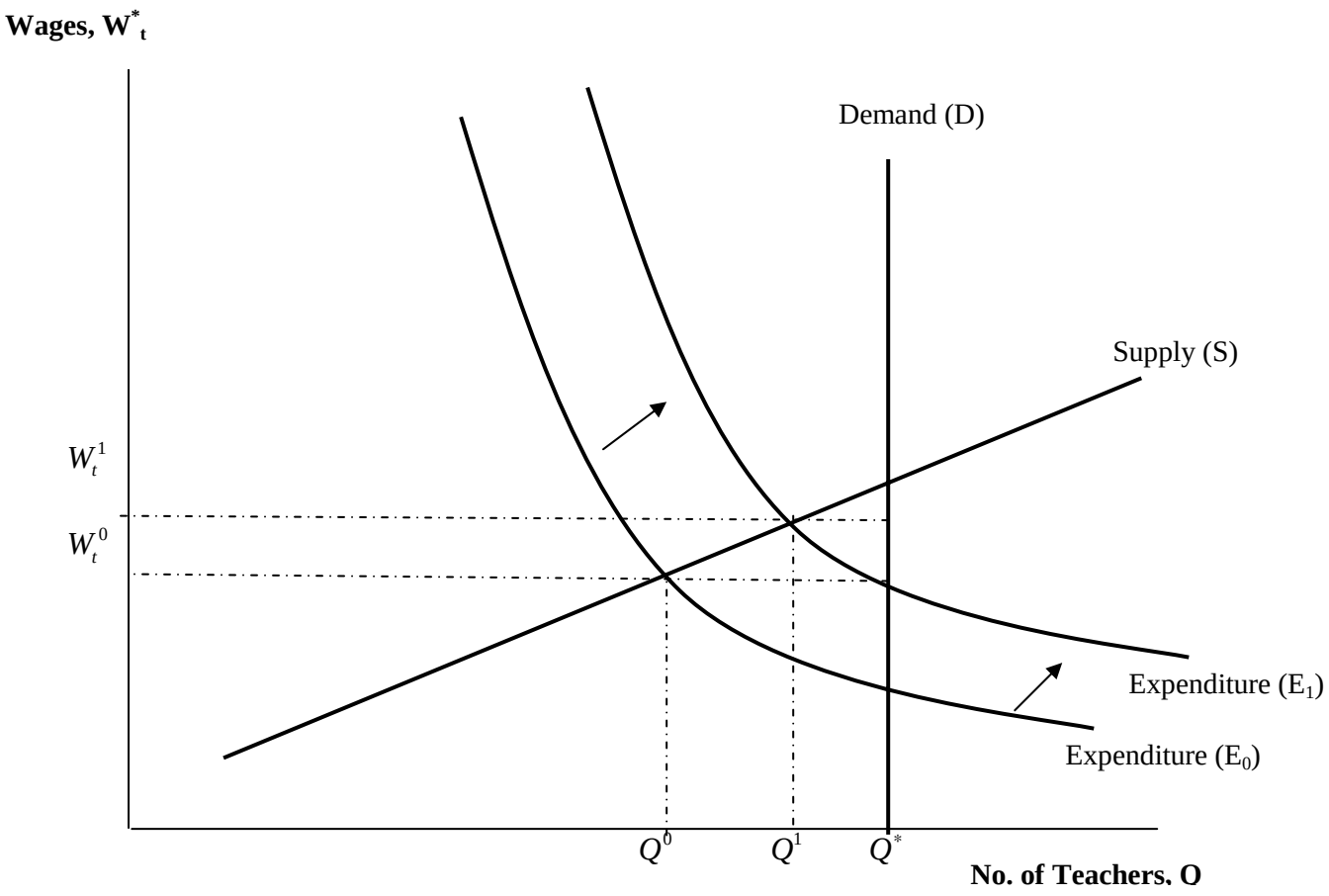
This shortage of teachers would only be alleviated if the government was responsive and was prepared to increase teacher earnings and so increase the level of its educational spending to cope with this shortage. In the event there would be upward pressure on the relative wage in teaching to alleviate this shortage.

Figure 4: Effect of Increasing Pupil Numbers or Lowering PTR.



The effect of an exogenous change in government spending on education is represented in Figure 5. Here a purely exogenous shift in government spending on teachers pay shifts the government budget constraint from E_0 to E_1. This results in a large number of teachers employed and this reduces the excess demand for teachers from (Q^*-Q^0) to (Q^*-Q^1) via the increase in teacher pay from W_t^0 to W_t^1.

Figure 5: Effect of Increased Government Spending on Education.



5. Measuring the Supply of Teachers.

The measurement of teacher supply and most specifically the possible changes in teacher supply from year to year is problematic.

In the data that is available in the UK there are a variety of ways in which this change in teacher supply can be measured:

1. Changes in the pool of inactive teachers, PIT. (By inactive, we refer to those who were previously in teaching or were trained as teachers and have either left the teaching profession or have not entered into teaching.)
2. Changes in the size of the pool of recoverable teachers, PRT.
3. Changes in the supply of teachers where the supply is measured according to the Zabalza definition. The supply of teachers as defined by Zabalza are the total number of people serving as a teacher (Zabalza, *et al.*, 1979)
4. The number of new entrants into teaching.
5. The number of those leaving teaching.
6. The number of people enrolling and leaving teacher training programmes.

Chart 1 shows the teacher demand and supply elements that is used to determine if the teacher labour market is in shortage or in surplus. 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 supply of teachers, which is the more problematic variable as we have set out at the beginning of this section.

The supply of teachers as portrayed in Chart 1 can be divided into two groups, the current supply of teachers and the potential supply. Within the current supply of teachers, this would constitute those who are currently in service in the teaching workforce. These teachers in service are denoted as *'s'* in our chart and would contain those who are continuing teachers (not in our chart), the new entrants *(e)* and the re-entrants *(rf)*. The new entrants are those who are first timers teaching in public schools while re-entrants are those with previous teaching experience in public schools, who left and are now returning to public school teaching. The number of students enrolled in the Initial Teacher Training (ITT) courses sustains the flow of new entrants as they complete and enter into the public sector teaching industry upon completion.

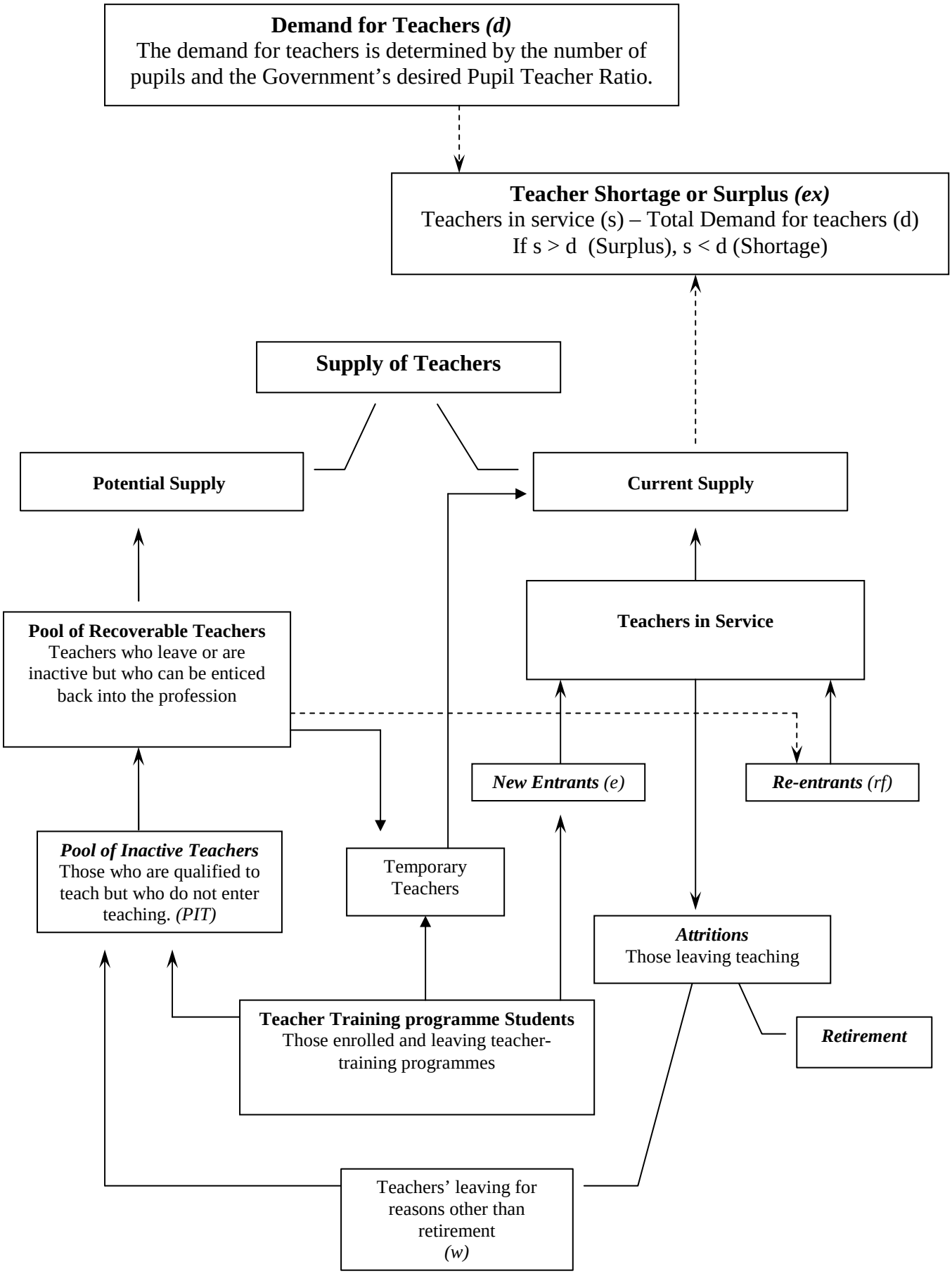
Shortages *(ex)* will occur when the *s* element in our model fails to meet the demand for teachers and vice versa, surpluses occur when the current supply of teachers exceeds the demand for teachers in the nation.

In completing the teacher supply and demand model, the outflow of teachers needs to be considered as well. Attritions form the outflow of teachers from the current supply. This group of leavers can be divided into those who leave due to attaining retirement age and those who leave for reasons other than retirement (i.e. those below the age of 60). When qualified teachers leave the profession, they become inactive and will enter our Pool of Inactive Teachers *(PIT)*, which we have placed as a sub-group of the potential supply of teachers in Chart 1. In addition to the leavers below retirement age, we also have ITT graduates who do not enter into teaching in the PIT. A second component in the potential supply of teachers is the pool of recoverable teachers. The teachers in the pool of recoverable teachers are those who leave but can be enticed to return to teaching and are therefore the main contributor to the potential supply of the nation's teacher stock. It should be appreciated that there are limitations with all these proxy measures of the supply of teachers.

The problem with using the PIT figures is that the calculation of these figures is subject to various assumptions about the retirement rate. The same is even more true of the PRT. Using the Zabalza definition of the number of people actually teaching does not give an adequate idea of the number of people who could teach. The number of people in post determines the actual number of people in teaching. It takes no account of the number of vacancies or the number of unemployed teachers who are seeking jobs but cannot find them. Importantly there may be a geographical mismatch of those seeking teaching jobs and where the vacancies are. In the UK there are many more vacancies in London and the South East but many more trained teachers who are not in work but seeking jobs in the North of England.

Using the wastage or attrition from teaching as a measure of supply is clearly indicative of the outflow rate from teaching but takes no account of the inflow rate. The problems with using the numbers entering and leaving ITT are that this gives one an impression of only part of the inflow rate. Other streams in the inflow are those who are possible re-entrants to teaching.

Chart 1: Teacher Demand and Supply



6. The Literature on the Supply of Teachers and other Qualified Workers.

There is a relatively small economics literature on the supply of qualified workers in different sectors. A most comprehensive early work on the supply of qualified manpower is the work of Payne (1960) who describes the nature of those who are qualified to work in the area of science and engineering. He does a thorough job of describing in empirical detail all the available evidence on the numbers graduating from universities and those in technology and technical training programmes. He charts the rise of educational qualifications in Britain in the early post war period. A few slightly later papers –Freeman (1975), Bosworth and Wilson (1980) and Whitfield (1985), Freeman (1989) respectively consider the market for: scientists and engineers and chemists and physicists. There are even fewer contributions on the specific question of the extent to which the economic cycle affects the supply of workers to a specific occupation. The contributions in the Lindley (1980) volume relate both supply and demand to a 'growth accounting' model of trends in employment and wages in the economy and by sector. However they do not estimate an econometric model of what macroeconomic factors determine the supply of qualified manpower. One contribution, which does relate the supply of occupation specific manpower to macroeconomic variables, is the first chapter in Freeman (1989) who describes the role of R&D and Federal U.S. Science budget spending on the markets for physicists. However such expenditure patterns are more related to the explicit demand for scientists than to movements in the macroeconomy.

One factor, which does emerge as important in the above work, is the suggested role of the declining rate of return[8] to a specific occupation in determining the possible future supply of potential entrants to the job. This theme has been picked up by Freeman (1976), Wilson (1985) and others. Such evidence is an alternative way of recasting the importance of occupational specific relative wages in the determination of future supply to a given occupation.

An important advantage in the consideration of the supply of scientific manpower is that it is fairly accurate to take as the potential total supply of scientists and engineers the total of young people who qualify in these subjects from university and add it to the stock of those already in jobs or who have qualified in previous years and are presently out of the labour

[8] The rate of return is the gain earned from the investment of resources in an economic activity. This rate is usually measured via a human capital model utilising the earnings Function.

force. The calculation of the potential supply of teachers is a lot more uncertain simply because the range of people who could train to be a teacher is large and diverse. In the extreme interpretation the potential supply of teachers consists of all graduates past and present and all other groups of qualified workers who could retrain accordingly. Clearly it is not appropriate to consider such a wide concept of the potential supply of teachers as the vast majority of these people will not consider becoming a teacher. However this does not detract from the fact that each year many recruits to teacher training come from the ranks of business and the professions and simply want to retrain. This group is a small proportion of the total supply of potential new teachers.

One growing literature, which relates the overall supply of graduates to the market for skills and the allocation of graduates to jobs, is that on overeducation. Many contributions to this literature (for example Freeman (1976) and Mason (1995)) see the main problem as the massive expansion of the supply of graduates in the UK as the cause of the over-supply of qualified manpower relative to demand. This has lead to many graduates not being able to get graduate jobs and a downgrading of the jobs which graduates are willing to take. This means that the market pressure associated with over supply may mean that many graduates who would not normally consider teaching as a career alternative may do so in times of excess supply of graduate manpower and high graduate unemployment. The original description of the problem of over supply of graduate manpower by Freeman (1975, 1976) also described how the market out of equilibrium may cycle in a cobweb fashion causing fluctuations in the demand and supply of graduates and the corresponding market wages that would result. In most graduate labour markets in the UK, it is clear that the leads and lags to such fluctuations could cycle over several years. This can be seen in the cyclical relationship between graduate unemployment and aggregate unemployment in the UK economy, which is described in Bee and Dolton (1990).

A large literature exists on the factors affecting the supply decisions of teachers, most of it originating in the US. This literature can be divided into studies that examine the influences on the decision to enter teaching, and the influences on the decision to exit from teaching. A few studies also consider quality aspects of teachers.

Considering first the entry decision, British work on this topic is limited. Dolton (1990) uses data from the 1980 Graduate Cohort, which follows a sample of graduates for up to seven

years after they have graduated. In this, and most other work in this area, 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 is the growth over time in teachers' earnings, and the lower is the growth in earnings of non-teachers.

A much earlier study, based only on time series data at the aggregate level in the UK for the years 1963-1971 by Zabalza *et al* (1979), estimates the elasticity of the supply of labour into teaching,[9] with respect to relative teacher earnings. The estimated elasticities 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 (1979a), 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[10] 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.

[9] The elasticity measured by Zabalza, *et al* is the wage elasticity, which refers to the percentage change in the supply of teachers as a result of a one % increase in the relative wages of teachers.
[10] 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.

There are a similarly small number of US studies to have considered the entry decision into the teaching profession. An example is Manski (1987), who uses data from the National Longitudinal Survey of the High School Class of 1972. The results of his probit equation on occupational choice (teacher/non-teacher) suggest a 10% increase in weekly teaching earnings will raise the supply of teachers from 19% to 24% of the graduate cohort. Manski also considers the quality aspect, and calculates that a 10% increase in weekly teaching earnings, coupled with a minimum requirement for entrance to the profession of an 800 SAT score, would maintain the supply of teachers at 19% of the cohort, while raising the average academic ability amongst that group to the national average for college graduates. Another example includes Zarkin (1995). By incorporating a forecastable future market condition into an occupational choice model, Zarkin (1985) looks into the expected new entrants to teaching at the Elementary and Secondary schooling level in the USA. Two variables on children, i.e. lagged number of children and future number of children are used to determine if the forecastable future market is important in a person's decision to enter into teaching. If the former is significant, the inference is to reject the forecastable model while if the latter is significant, future considerations are important in determining the supply of new entrants to teaching. He breaks down his analysis further by gender and his results shows that the determinants of entering teaching at the two schooling level are different. At the Elementary school level, the lagged number of children was significant for female teachers, while at the secondary schooling level for both males and females; the future number of children was significant. He attributes these results to the proportion of male and female teachers in each of the schooling level. At the Elementary schooling level, there appeared to be a larger proportion of female teachers who have a shorter labour force participation. Due to this, future expectations were not found to be important for this group of teachers. On the other hand, in the Secondary schooling level, there were a higher proportion of male teachers. In contrast to their female counterparts, they generally have higher average lifetime labour force participation rates. Therefore future considerations were important to them.

There are more studies examining the decision to continue in or exit from teaching. Most of the British work in this area has been undertaken using information on various cohorts of university graduates, for example Dolton (1990), Dolton and van der Klaauw (1995a, 1995b, 1999) and Dolton and Mavromaras (1994). With the exception of the last of these studies, all use data from the 1980 Graduate Cohort.

The Dolton (1990) study estimates a probit equation on whether an individual is in a teaching job seven years after graduating (conditional on choosing a teaching job as the first job upon graduation). The results suggest that the factors affecting the decision to continue teaching are very similar to those that affect the decision to become a teacher in the first place. The three papers by Dolton and van der Klaauw all adopt a hazard approach to model the length of time spent in the first job after graduation amongst teachers. The results show that the elasticity of leaving a teaching job with respect to relative wages is about –1.5, suggesting a large reduction in quit behaviour amongst teachers, following a rise in earnings. The importance of the outside labour market and alternative opportunities is also clearly demonstrated by the significance of other variables in the estimated equation. In particular, teachers are more likely to leave their jobs, if their local unemployment rate is low, if they have a professional qualification and if they hold a non-education first degree. When Dolton and van der Klaauw (1995b, 1999) extend earlier (1995a) work by adopting a 'competing risks' approach to their hazard rate, allowing the explanatory variables to have a differential impact on the likelihood of leaving for non-teaching work, and the likelihood of leaving the labour force altogether, they find that a higher teaching wage reduces the probability of teachers 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.

The final paper to use the UK graduate cohort data sets is that of Dolton and Mavromaras (1994), which, using data from both the 1970 and the 1980 cohorts, is the only one to provide, as we do here, comparisons over time. The authors decompose the cause of the fall in the likelihood of becoming a teacher between these two dates into 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.

As with the entry into teaching decision, Zabalza *et al* (1979) also undertake a time series analysis of the exit decision, considering the years 1963-1972. As with the Dolton and Mavromaras (1994) study above, they find that males are much more likely to be influenced by wages than females, the elasticity of the trained graduate separation rate with respect to relative wages being –2.4 to –3.0 for men, and –0.6 to –0.7 for women. Unlike their analysis of the entry decision, Zabalza *et al* find that this gender differential in wage effects exists for both starting wages and the growth in wages.

There is only one paper, as far as we know which explicitly examines the relation between the aggregate fluctuations in the economy and its effects on teacher supply in the UK. This recent, internal DfES working paper (DfES, 2002) examines the relationship between the log of attrition rates in teaching for men and women over the 1970 to 2000 period. The authors find a significant effect of the economic cycle, as measured by changing GDP, on the attrition rates of people leaving teaching. They find that the effect of the economic cycle is marked for both men and women. Our analysis differs in a number of key respects:

- We explore a variety of different concepts of potential and actual supply as well as simply the attrition rate. Additionally, our attrition rate encompasses a longer age range as compared to that used in the DfES paper. In the latter, attritions covered those aged 21 to 49 while our attrition data includes all outflow of teachers below the age of 60.
- We have an array of extra controls ignored in the DfES paper including: graduate unemployment, trade union density, educational quality and other education-demographic variables.
- We use more rigorous econometric methods of time series analysis. This includes the testing of the variables for stationarity and an exploration of the concept of an economic cycle. We eliminate the rather arbitrary use of moving averages and logged variables in our estimations.
- Finally we have a longer run of time series data from 1955-2000 in the case of some variables.

In the USA, an early paper by Maaske (1951) provides a historical perspective on the teacher labour market in the USA from 1900-1950 by examining the relationship between the year of teacher surplus, shortage or balance and years of economic prosperity or depression. He tries to establish the evidence of the inter-relationship between these two variables but does not provide any statistical or econometric evidence.

Turning to the US literature on the continuation or exit decision, the evidence closest in spirit to the UK studies using the graduate cohort data sets is provided in two papers by Stinebrickner (1998, 2001), using data from the National Longitudinal Study of the High School Class of 1972. As was found with the UK studies, Stinebrickner (1998) suggests that teachers are more likely to stay in their job the higher are the wages that they receive. Stinebrickner (2001) simulates the effects of changing teacher wages. Two policies are

considered, the first being a 25% pay increase for all teachers, and the second being a 25% pay increase on average, the actual amount depending linearly on teachers' SAT scores. The results of the simulation show that the proportion of the eleven years under consideration that the initial teachers spend in teaching, rises from 0.48 to 0.72 under both of these policies, with wage increases being particularly likely to reduce the amount of time spent in non-teaching employment, rather time spent out of the labour force altogether. The second policy, whereby wages are increased in proportion with teacher quality, leads to a change in the mix of teachers towards a greater proportion of those of high quality. A limited number of other papers have also considered this quality aspect. For example, Ballou and Podgursky (1995) suggest that wage rises must be implemented together with an attempt to target those of higher ability, or, more cost effectively, making the pay rise conditional on having a certain minimum SAT score, if quality is to increase. In a similar vein, Hanushek *et al* (1999), using data for the years 1993-1996 from the UTD Texas Schools Project database, show that a 10% increase in starting wages is associated with a 2% fall in the probability of leaving for probationary teachers, and a 1% fall for those with 3-5 years of experience. The same wage increase is also associated with higher maths and reading achievement amongst pupils of 0.17 and 0.11 standard deviations respectively.

Summarising the remaining US papers to have studied the exit decisions of teachers, many have used state level data on all teachers registered within particular states, including Brewer (1996,) Rees (1991), Mont and Rees (1996) (all studying New York), Murnane and Olsen (1989) (Michigan), Murnane and Olsen (1990) (North Carolina), Theobald (1990), and Theobald and Gritz (1996) (both Washington). All agree that the salary paid to teachers is negatively related to their propensity to leave, or positively related to the duration spent in first teaching jobs. Where studies allow for gender differences, a common finding is that these wage effects are higher for men than for women. In addition, the results generally show that teachers with higher level qualifications, or who live in areas with higher average non-teaching wages, and more likely to leave their teaching jobs.

Finally, in examining the demand and supply of teachers in the USA using State data between 1975-1990, Flyer and Rosen (1997) concluded that the demand for teachers has risen over time, mainly caused by increasing teacher-pupil ratio in the USA while the supply price of successive cohorts of teachers have also been rising. They also conclude that the higher the female labour force participation, the higher the teacher-pupil ratio when the correlation between female labour force participation and teacher-pupil ratio in the USA was positive

and significant.[11] Women were entering into the teaching labour market because it is a flexible career option which is compatible with household production. This progression also offers the possibility of leaving without suffering a penalty on wages. In supporting the latter reason, Flyer and Rosen found that those who left the teaching force and returning later on earned the same wages as before while those who were in other occupations had suffered a loss of approximately 10 % of their previous wage level when they re-entered the labour work force.

7. The Supply of Teachers and the Economic Cycle in the UK.

From the above section, we can see that the supply of teachers in the UK using a set of time series data has been examined fairly extensively by Zabalza (1979a, 1979b). Later papers include those by Bee and Dolton (1995) and Dolton and Robson (1996). The examination of teacher supply of this nature has been made possible with the availability of data over time taken from different published sources. The time series data that we have on teachers in the UK extends from 1947 to 2000[12].

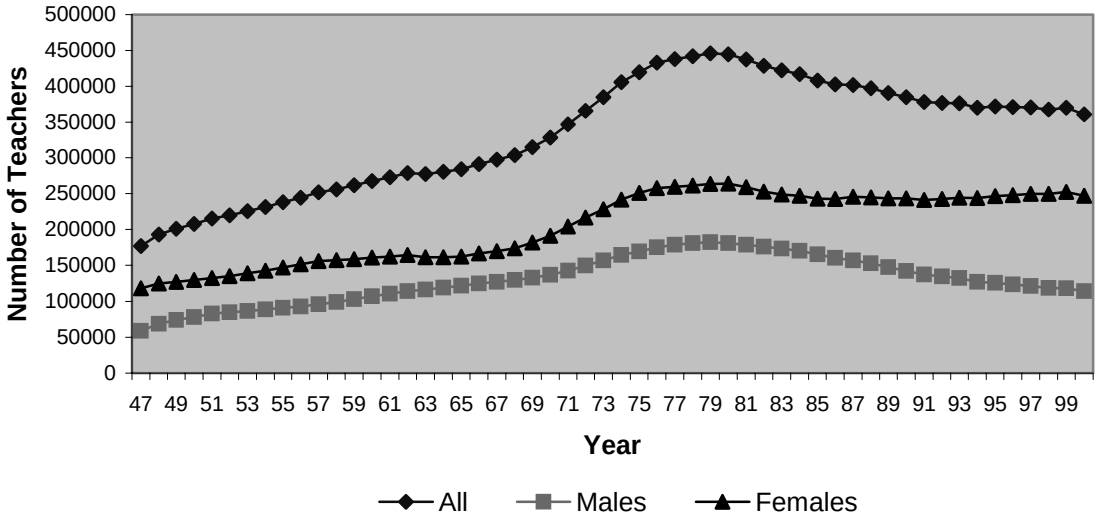
The task of this section is to empirically examine the teacher supply position in the UK. We will attempt to look at the trend of the different elements of teacher supply measurements as shown in Chart 1. In the first instance, we examine the current supply of teachers, i.e. teachers in service. Over the time period of our data, the highest average rate of increase among teacher numbers occurred in the 1970s where teacher numbers were growing on an annual average of 4 %. This situation lead to a change in the shortage of teachers to a surplus of teachers which motivated Zabalza's (1979b) paper on the shift of an excess in the demand of teachers to a condition of teacher surpluses. Following this period of surplus, the next two decades saw a decrease in the number of teachers with the 1980s indicating an average annual decline of 1 % and for the period 1990 to the year 2000, we see an average annual decrease of 0.7 %.

Figure 6 depicts the situation of teachers in service in the UK for the period 1947 to 2000. A similar pattern is observed among the male and female teachers. The ratio of female-male teachers in the UK for the period 1947 to 2000 averages 60:40. This phenomenon of teachers in the UK being predominantly female follows that found in other OECD countries (Santiago,

[11] This finding was robust throughout all the different specification tested.
[12] Some variables are only available over a shorter time span.

2002). We observe this pattern in all of the other teacher supply variables, which we present in this remaining section.

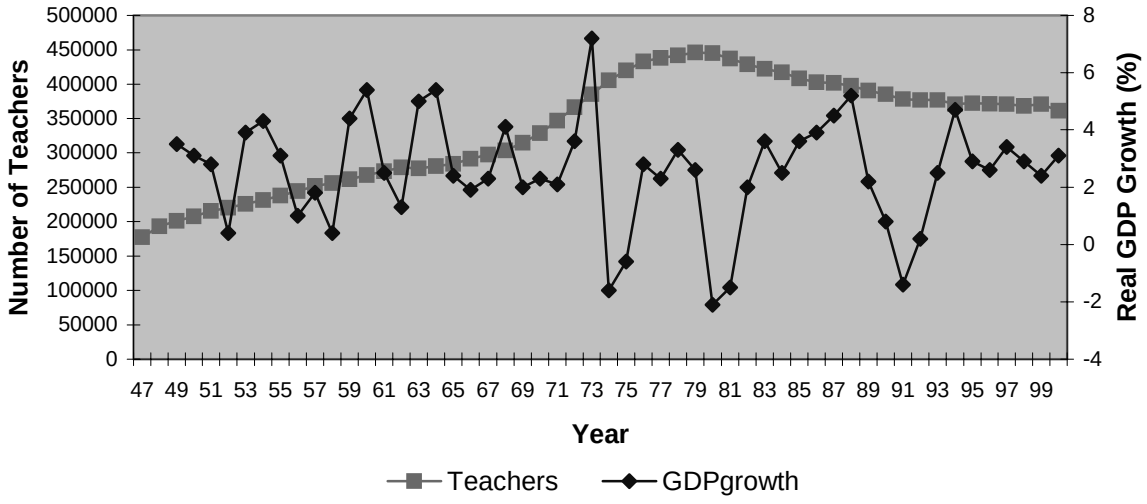
Figure 6: Teachers in Service, UK 1947-2000



Source: Statistics of Education

If we associate the teachers in service trend with real GDP changes over time, we find that the graphical description does not indicate any clear correlation between the two variables (see Figure 7). Running a simple correlation test on these two variables indicate a low negative and insignificant correlation between the two variables.

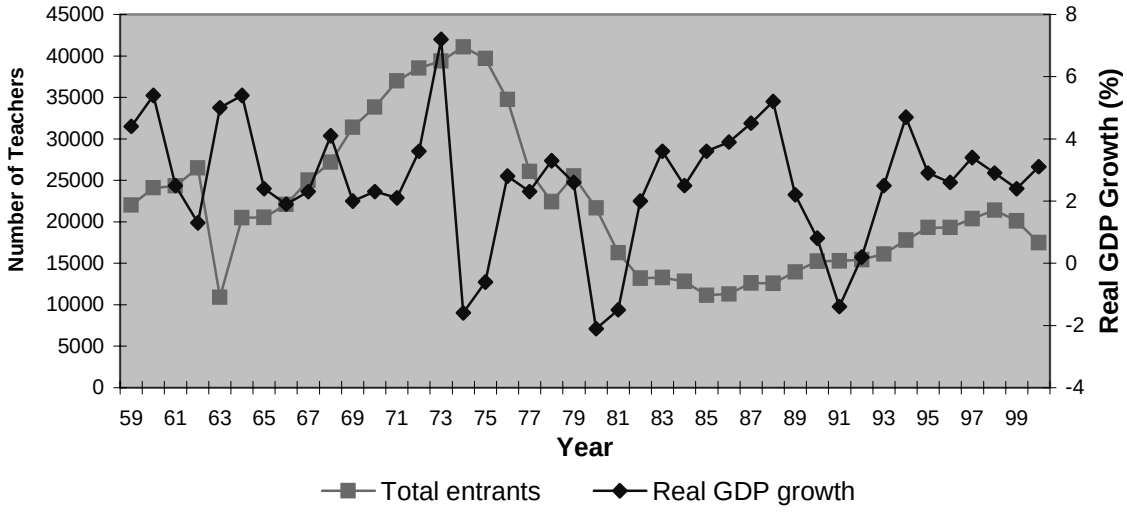
Figure 7: Teacher Supply and Real GDP Growth, UK 1947-2000



Source: Statistics of Education and ONS

In Chart 1, the current supply of teachers constitute teachers who are currently in service, new entrants, i.e. first timers in public school teaching and the re-entrants, i.e. those who had left but returned to teaching at some point in time. Graphically, there appears to be a negative relationship between the number of new entrants into teaching and real GDP growth (see Figure 8). When there is rising real GDP growth, the total number of entrants indicates a decline. The male and female trends appear similar to that at the overall level.

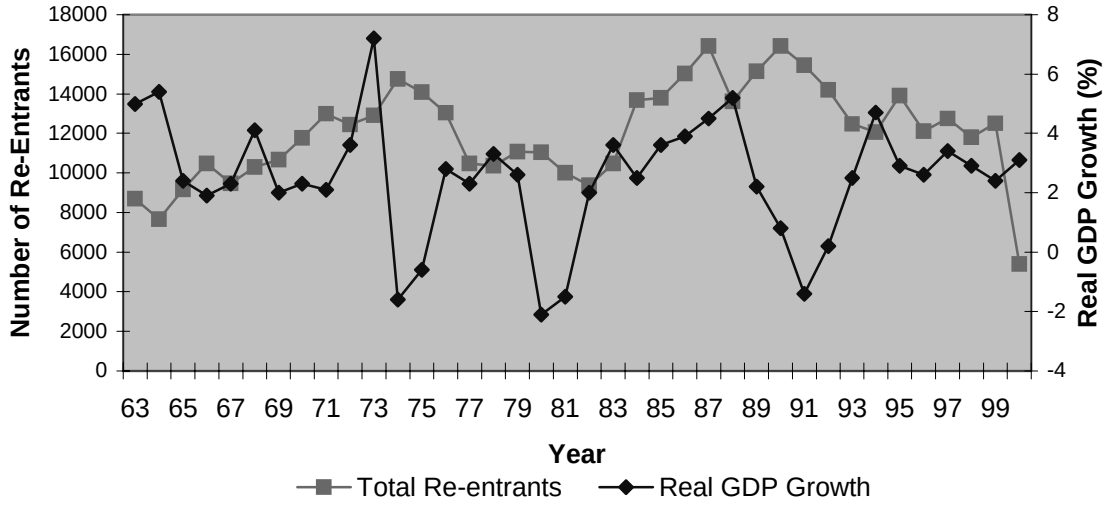
Figure 8: Total Entrants and Real GDP Growth, UK 1959-2000



Source: Statistics of Education and ONS

Figure 9 shows the trend of the number of re-entrants into the teaching profession in the UK and its relationship with real GDP growth. A simple spearman correlation analysis indicates that there is a negative and insignificant relationship between these two variables. However, on close scrutiny of the graph, we find a mix in the relationship outcome of the number of re-entrants and real GDP growth. For example, when we examine the period of the first oil crisis in 1975; we find that as real GDP growth increases from 1974 to 1975, the number of re-entrants declines for the same period in discussion. However, when we look at the period of 1985 to 1988, as real GDP growth increases, the number of teachers re-entering into teaching increases. This positive relationship is in contrast to what we observed in the earlier 1974-1975 period. The trend in the 1990s on the other hand takes us back to the negative relationship, which we saw in the mid-1970s whereby there is an increasing trend in real GDP growth during the period 1991 to 1994 but the number of re-entering teachers decreases for that same time period.

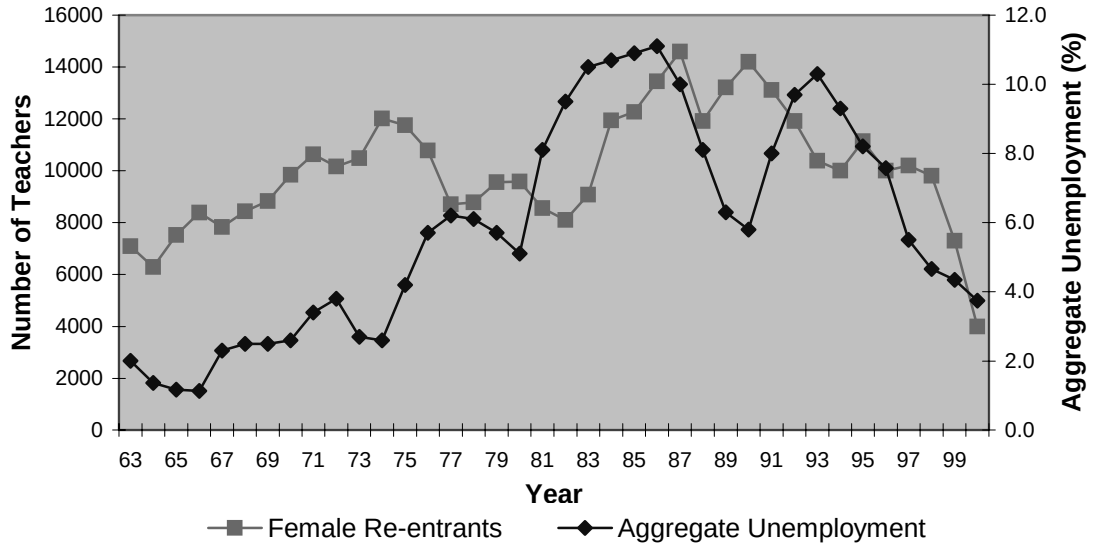
Figure 9: Total Re-entrants and Real GDP Growth, UK 1963-2000



Source: Statistics of Education and ONS

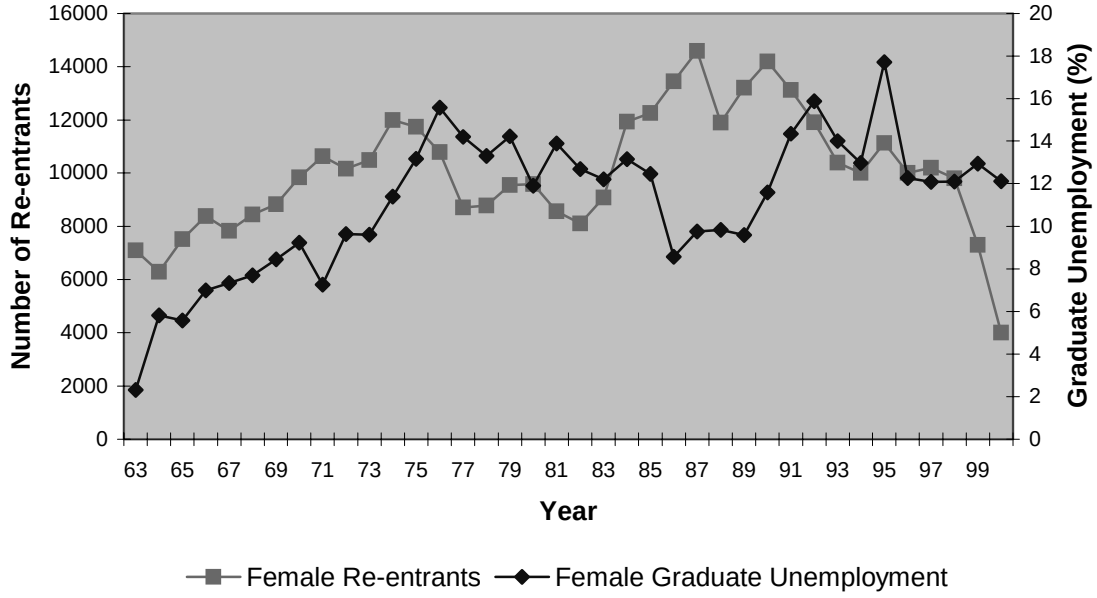
While the relationship between real GDP growth and the number of re-entrants appear unclear, we find that there is a positive and significant relationship between female re-entrants and aggregate unemployment. In Figure 10, as aggregate unemployment increases in the UK, the number of female re-entrants increases as well. This perhaps indicates that to a certain extent, female teachers value their teaching position when employment conditions deteriorate in the economy. This relationship between re-entrants and aggregate unemployment at the total level and for males is negative and insignificant. Figure 11 depicting female graduate unemployment and female re-entrants confirm the latter condition.

Figure 10: Female Re-entrants and Aggregate Unemployment, UK 1963-2000



Source: Statistics of Education and ONS

Figure 11: Female Re-entrants and Female Graduate Unemployment, UK 1963-2000

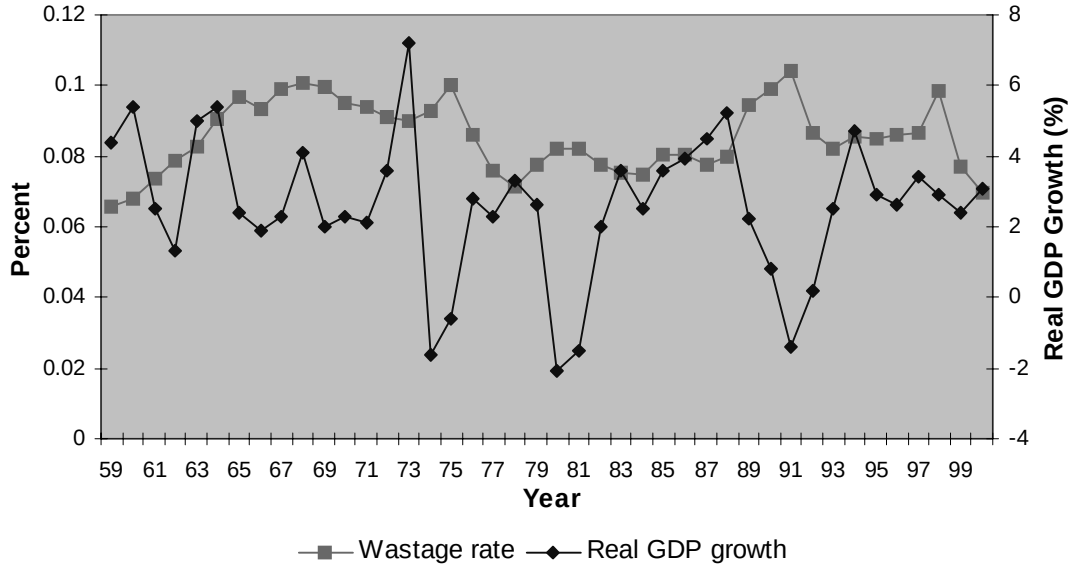


Source: Statistics of Education and ONS

We have so far examined the trends in the inflow of the current supply of teachers in the UK. Within the current supply of teachers, there are the outflows of teachers, which we label as the number of attritions in the teaching profession. In Chart 1, the number of attritions consists of those who are of retirement age and those who leave for reasons other than retirement. It is this latter group that would be of interest given that there are possibilities that some of them could return to teaching if conditions were conducive.

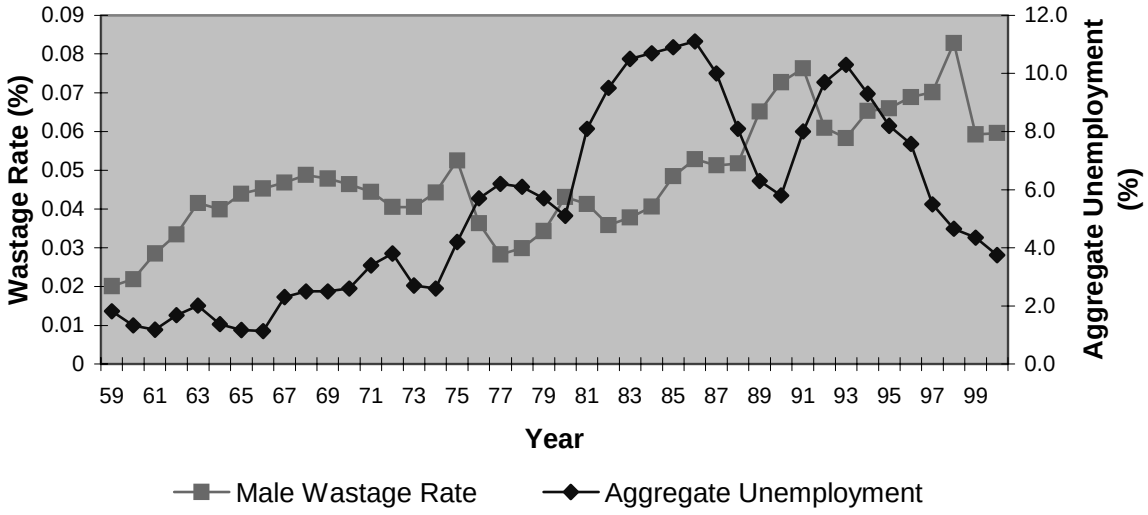
Figure 12 shows the attrition rate and its relationship with real GDP growth. There appears to be a negative relationship between the attrition rate and real GDP growth. As real GDP growth increased, the attrition rates declined at the overall level and vice versa, when real GDP growth decreases, attrition rates increases. We find a similar trend in the attrition rates for males and females and real GDP growth. This negative relationship seems to indicate that teachers may not find the profession stable as they seem to be willing to leave even when the economy is not doing well. Between the males and females, it appears that this latter reason may be dominant among the males as we find a positive relationship between the attrition rates for men and aggregate unemployment. The male teacher attrition rate appears to be increasing as aggregate unemployment increases and this relationship is significant at the 5 % significant level from the Spearman correlation test. Figure 13 shows the male attrition rate and aggregate unemployment. A similar relationship occurs between male attrition rate and male graduate unemployment (See Figure 14).

Figure 12: Attrition Rate and Real GDP Growth, UK 1959-2000



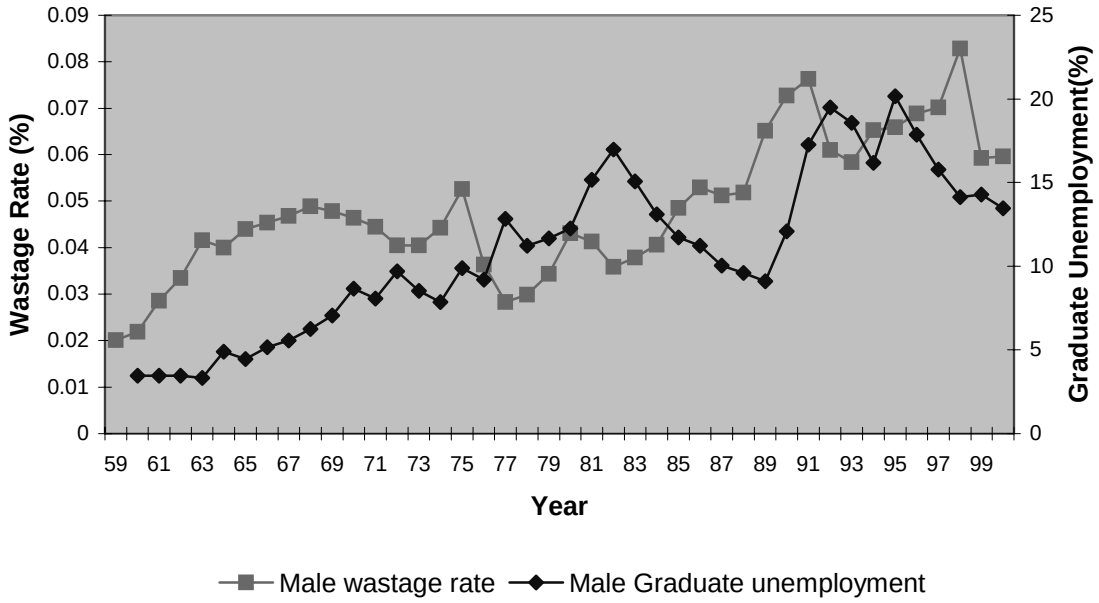
Source: Statistics of Education and ONS

Figure 13: Male Attrition Rate and Aggregate Unemployment, UK 1959-2000



Source: Statistics of Education and ONS

Figure 14: Male Attrition Rate and Male Graduate Unemployment, UK 1959-2000



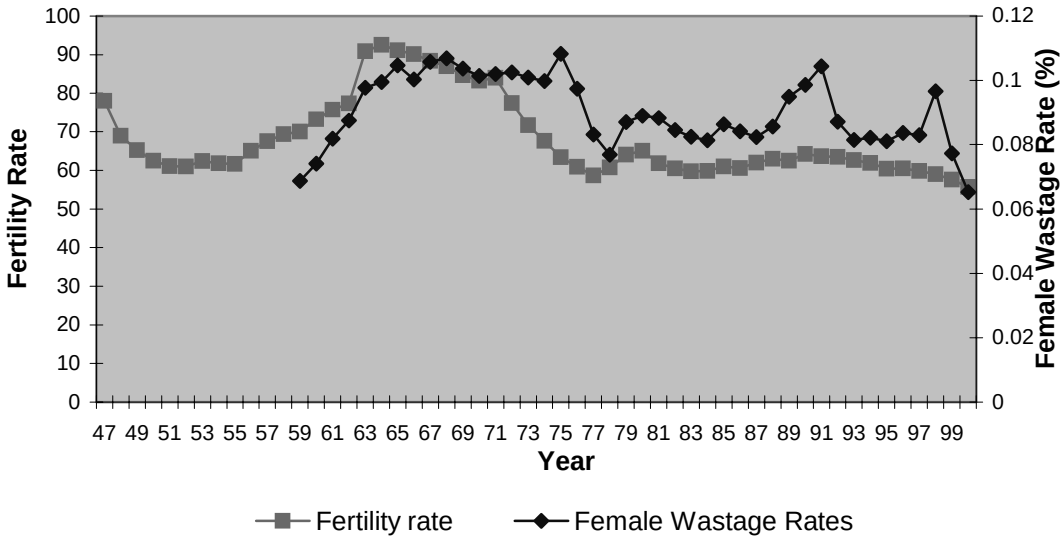
Source: Statistics of Education and ONS

For the females, a negative relationship is prevalent between the female attrition rate and aggregate unemployment. Although it conforms to expectations, i.e. females will not leave as aggregate unemployment increases, this group would still be worthy of further scrutiny. Being the dominant contributor of teacher supply between the two genders, there would be a need to be able to identify why female teachers leave the profession. Logically, women are

more likely to leave the workforce for household responsibilities especially after childbearing. In addition to knowing why female teachers leave the profession, it would also be important to be able to identify if those who leave will return to teaching. Waldfogel, et al. (1998), using the 1979-1993 National Child Development Study (NCDS) data, found that 52 % of females in Britain had returned to work for the same employer after childbirth. This gives us an indication that approximately 48 % of them do not return to employment (noting that this is a crude approximation given that there could be some women who would return to the workforce but with a different employer).

In our data set, we estimate that approximately 55 % of women teachers who leave the profession will not return to teaching.[13] It is this 55 % of women who would be the potential supply of teachers and will form part of the pool of recoverable teachers (PRT) in the UK. Returning briefly to our discussion on the reason for female teachers to leave teaching, Figure 15 shows that there could exist a close relationship between fertility rates[14] among women and female attrition rates.

Figure 15: Fertility Rate and Female Attrition Rate, UK 1947-2000



Source: Statistics of Education and Annual Abstract of Statistics

As noted in the above paragraph and in Chart 1, the supply of teachers can be enhanced with the existence of a group of teachers whom we consider as potential supply. Two groups of

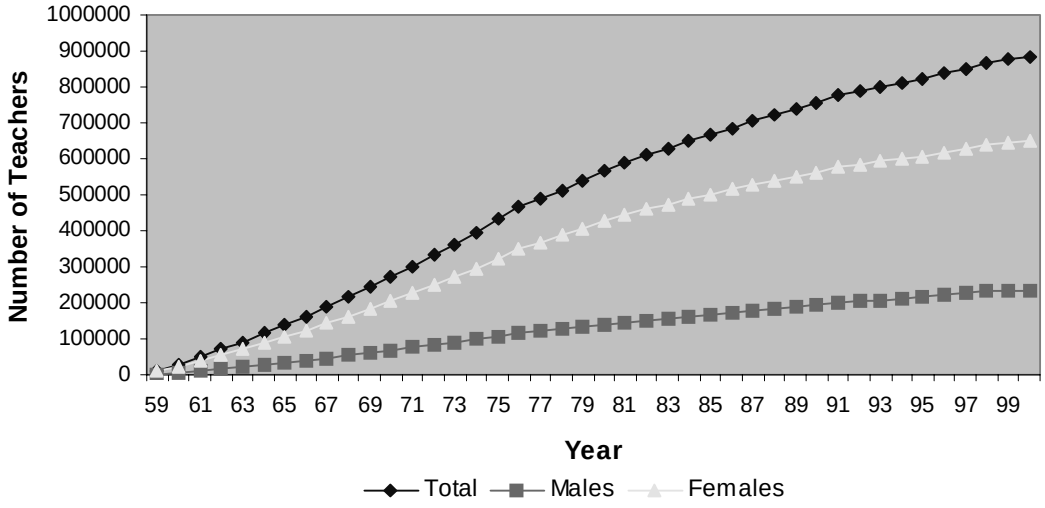
[13] This figure was calculated by looking at the aggregate numbers of re-entrants over the last 30 years as a fraction of all below the age of 60 who leave.
[14] Fertility rates used are rates per 1000 women aged 15-44.

people are the main source of this potential supply of teachers. Firstly, they are the pool of inactive teachers (PIT), i.e. persons who are qualified to teach but do not enter teaching and secondly, out of these inactive teachers, there are those who can be attracted back into the profession. This latter group of teachers is the pool of recoverable teachers (PRT). The data appendix provides an explanation as to how these two variables are derived in our data set. Figure 16 graphs preliminary estimates of the PIT. These calculations grossly under-estimate the numbers in the stock of trained teachers who are not working in teaching in 1959 and the early 1960s. This is because we do not have good estimates of the size of this stock at the beginning of the period of our data. In order to compute the size of this stock over time we accumulate figures relating to those who train but do not enter in any given year and those who leave prior to retirement. Hence our figures become a better estimate of the size of this stock as time passes.

Indeed by the late 1980s we can be reasonably confident that our data provides a good estimate of the PIT since many of the stock in 1959 would, by then have reached retirement age and hence not be eligible members of the PIT. In the meantime we do not intend to use the raw PIT figure as a measure of supply but only the change in the PIT as evidence of how potential supply is adjusting.

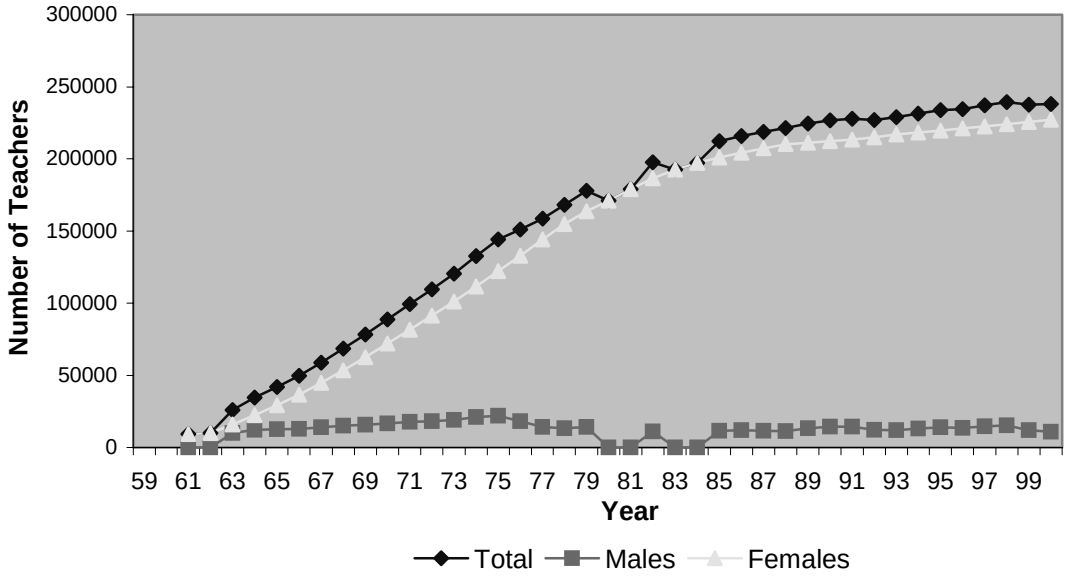
In the UK, Figure 16 indicates that there is an increasing number of teachers who are qualified but who are not presently working in the profession. This increasing number raises the question as to why this group of qualified teachers are not entering the occupation that they were trained for. However, at the same time, this is the group of teachers who are a potential source in helping solve the teacher shortage problem, which has been prevalent in the past two decades.

Figure 16: Pool of Inactive Teachers (PIT), UK 1959-2000



Source: Own calculations

Figure 17: Pool of Recoverable Teachers (PRT)[15], UK 1961-2000



Source: Own calculations

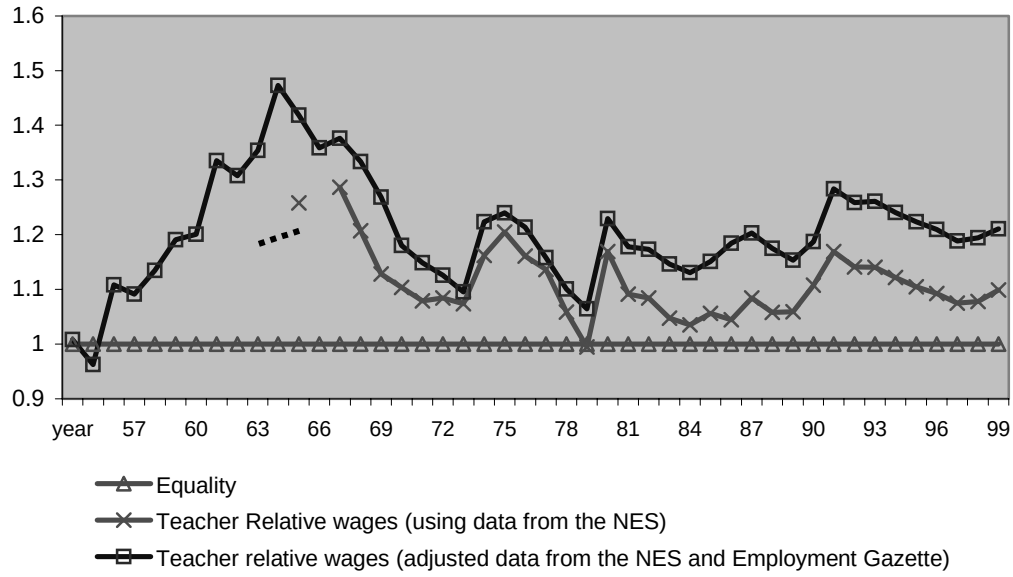
Out of the PIT, we have the resource of the pool of recoverable teachers (PRT), i.e. teachers who leave the profession but who can be attracted to return to the teaching service. The number of teachers who can be "recovered" is on the increase over the past 5 decades in the UK (see Figure 17 above). These two sub-groups of potential supply of teachers could be

[15] The pool of recoverable male teachers are low relative to the female pool as we have considered the pool of recoverable male teachers as a flow whereby each year is treated separately.

possible sources of teachers in solving the excess demand situation that we will examine later in this section.

Having observed the trends of teacher supply in the UK and from the literature that is available on teachers, we recognise that teachers' pay relative to other graduate occupations is of prime importance, since it is relevant to consider how graduates make choices between becoming a teacher and taking up another occupation. Figure 18 graphs the relative earnings of teachers compared to average non-manual earnings and national average earnings.[16] The highest relative wages were paid to teachers in the mid-1960s, followed by a considerable deterioration in the period up to 1973.

Figure 18: UK Relative Teachers' Wages



Source: Own calculations

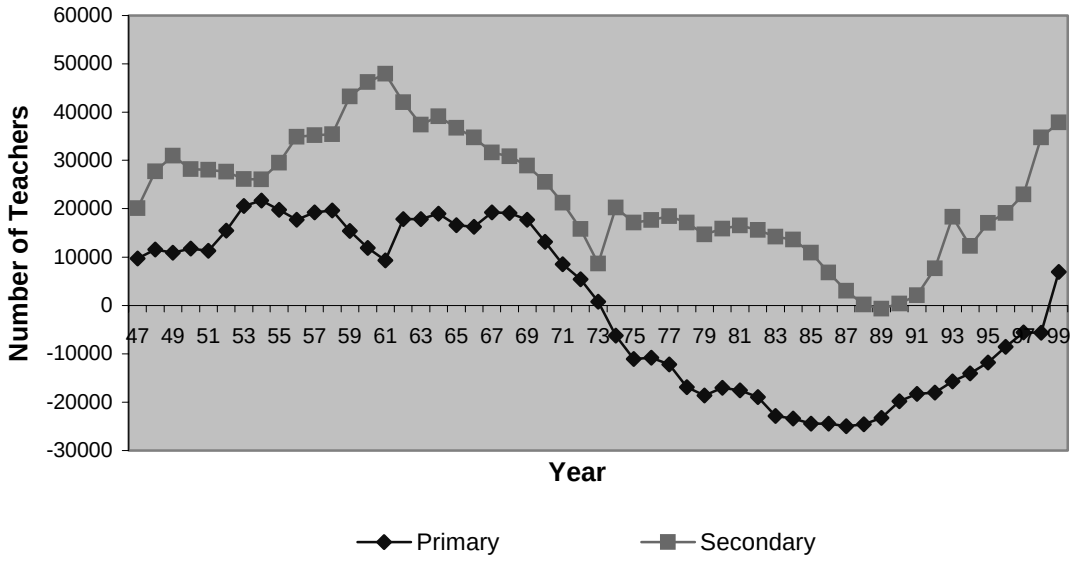
There followed a series of dramatic adjustments after the Houghton Report (1974) and the Clegg Commission (1980) recommended that teachers' pay had been allowed to decline too far. More recently, the 1990s have seen a continuous decline in the relative wage of

[16] 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 18, we only display teachers' earnings relative to the non-manual average from 1968 onwards using the NES. We estimate the position relative to non-manual earnings for 1966 (to gauge the situation for our first cohort), by adding the average difference between the October Survey and NES

teachers, although of less dramatic extent than the decline of the late 1960s and early 1970s. Such fluctuations in the relative level of pay for teachers will be important for the interpretation of the teacher supply conditions that we have described above and in the econometric modelling on teachers and the economic cycle that will be conducted later in this paper.

When teacher supply is discussed, an element that is rarely left out is the demand side of the subject in discussion. The interaction between these two variables will tell us if there is a shortage or surplus of teachers in the public school market. The number of pupils and the Government's published targeted pupil teacher ratio determines the demand for teachers. For example, in 2000, there were 4,278,123 primary school children (full-time equivalents). The Government targeted that there would be 21.2 primary school children for every primary school teacher, implying that 210,798 primary school teachers are demanded. In actual fact, there were 183,762 primary school teachers in 2000, implying an excess demand for primary school teachers of 27,036. A similar analysis for secondary school teachers reveals that there was an excess demand of 15,952 teachers, giving the overall excess demand figure of approximately 34,000. Figure 19 uses this logic to chart the situation for all years since 1947.

Figure 19: Excess Demand of Teachers, by Sector, UK 1947-2000



Source: Own calculations

estimates of teachers' earnings relative to non-manual earnings (approximately 20 percentage points), to the October Survey estimate of the relative position for that year.

The graph shows that there has been an excess demand for teachers almost continuously throughout this period.[17] Therefore, it is important that we are able to further understand how the various measures of teacher supply (i.e. elements in both the current and potential supply, with the latter carrying more importance) could be utilised to meet the excess demand of teachers in the UK amidst changing economic conditions.

What this analysis omits is that for particular subjects such as Mathematics and Science, and particular areas, such as London and the South-East, which have suffered severe shortages at different points in time. The omission is due to the lack of a good set of data that would enable us to examine the teacher supply market in a disaggregated form.

In this section, we have described the teacher supply condition in the UK and have attempted to link it to examine the relationship that it has with the economic cycle. However, we have not considered other factors which are deemed to influence teacher supply and the economic cycle. The analysis by graphs only allows us to look at two variables at a time as we are not able to interact more than two variables using this two dimensional analysis. To consider these other factors, it is useful to examine the data that we have by applying our data to the econometric modelling that we will present in section 11 of this paper.

8. The Supply of Teachers and the Economic Cycle in the USA.

The teacher situation in the USA is different from that in the UK, in governance and in the way that teachers are recruited and hired. Dimmock (1980) suggests that the teacher labour market in the USA conforms more to a *laissez faire* model while the teacher labour market in the UK is one of intervention.

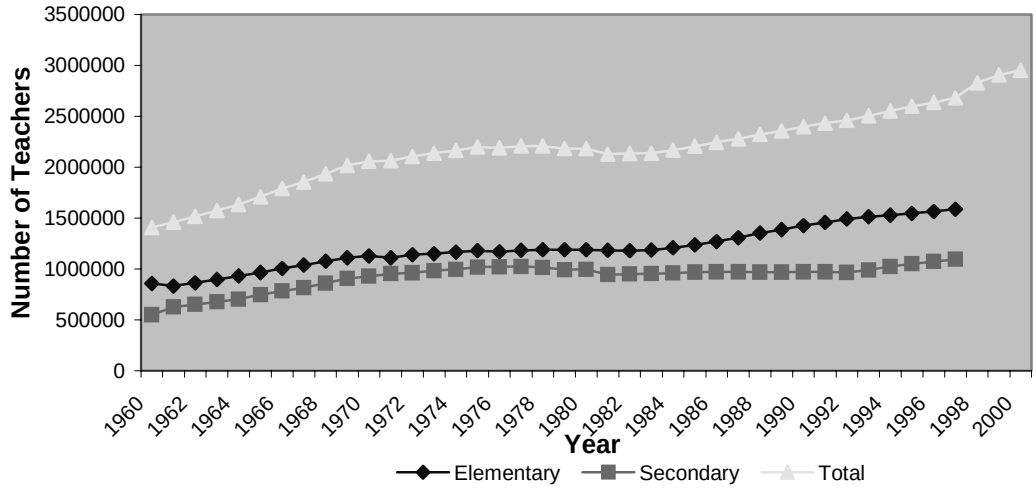
In the USA, each school district acts as the teacher employer, deciding on the teacher training requirement, recruitment and pay issues of the teacher while in the UK, the Government had close overall control on the direction of teacher training and the numbers being recruited in the profession until recent reforms to allow schools more decision making powers. Data wise, unlike in the UK, where annual numbers of teacher statistics are collected systematically, the USA does not have the luxury of a set of consistently collected teacher

[17] Note that in Figure 19, we have analysed the excess demand for teachers by the different school sectors. The total is not displayed, as it would be inaccurate to assume that primary school teachers could easily substitute the shortage for secondary school teachers. In reality, this substitution is difficult.

statistics. While we are able to obtain a minimal set of teacher numbers over time, other statistics available in the UK such as the number of new entrants, new graduate teachers, re-entrants and attrition rates are unavailable for the USA. The actual data on some of these groups of teachers (mainly leavers, mover and new entrants) are limited to the years when the National Center of Educational Statistics' School and Staffing Survey (SASS) is conducted. To our knowledge, the SASS was carried out in 1987-88, 1990-91 with follow-up surveys in 1988-89, 1991-92 and 1994-95. The most recent SASS carried out is the 1999-2000 survey.

Figure 20 shows the number of teachers in the USA from 1960 to 2000. The teacher numbers in the USA appears to be increasing throughout the 40-year period in our graph. Breaking it down into the different decades, the 1960s saw the highest growth in the number of teachers (at all levels) in the USA. This high growth in teacher employment was encouraged by the post-war baby boom period. The total number of teachers was growing at an average of 4 % in the 1960s, decreasing to 0.8 % in the 1970s and the 1980s and increased substantially by 2.07 % in the 1990s. The growth in the teacher numbers by each schooling level is similar to that found at the total level. Secondary school teachers were increasing faster than the Elementary school teachers with the exception of the 1980s where the Secondary school teacher's growth was negative (-0.23 %).

Figure 20: Number of Teachers in the USA, by Sector, 1960-2000[18]

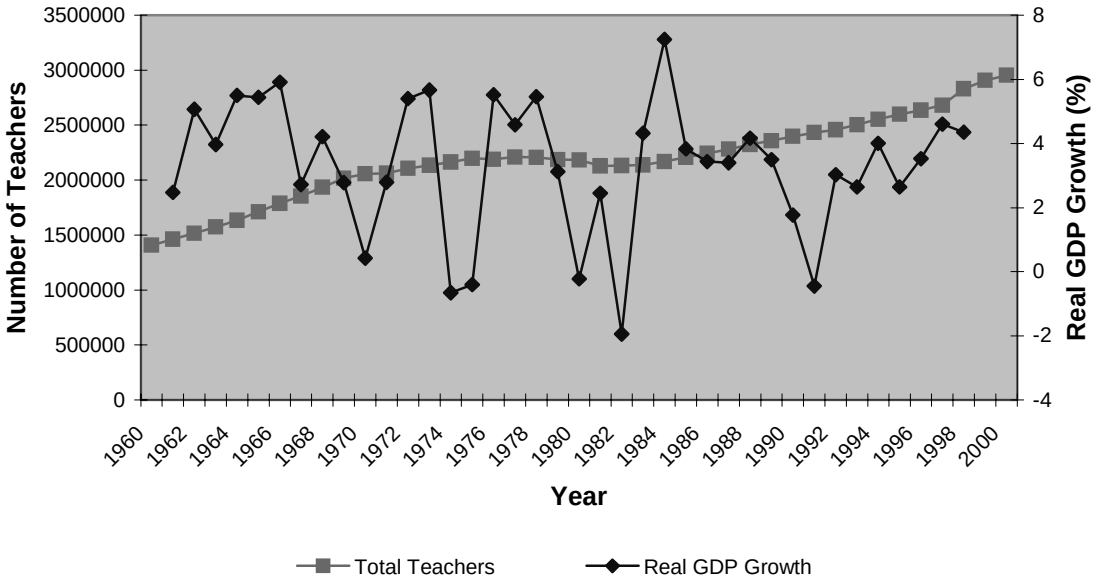


Source: NCES

[18] Data according to schooling levels were of a shorter time span as compared to the overall schooling level as the NCES had ceased publication of data by the Elementary and Secondary schooling level for the later years. Also, data for teachers are expressed in full-time equivalents.

Moving on to examining the relationship between the number of teachers in service and the real GDP growth in the USA, we find that (as that found in the UK), there does not appear to be a clear relationship between the two via our graphical description (See Figure 21). Statistically, the Bureau of Labor Statistics found that employment in the USA's Educational Services was one of the industries, which had the least correlation with business cycle fluctuations. In this study by Berman and Pfleeger (1997), the employment categories are aggregated under the category 'Education Services', which covered teachers, librarians, counsellors, teacher aides and educational assistants, janitors and food preparation and service workers. Although the category in which teachers were placed covered other occupations, at this stage, we have an indication that there could be a low correlation between teacher employment and GDP growth in the USA.

Figure 21: Total number of Teachers and Real GDP Growth, USA, 1960-2000



Source: NCES and the Bureau of Economic Analysis

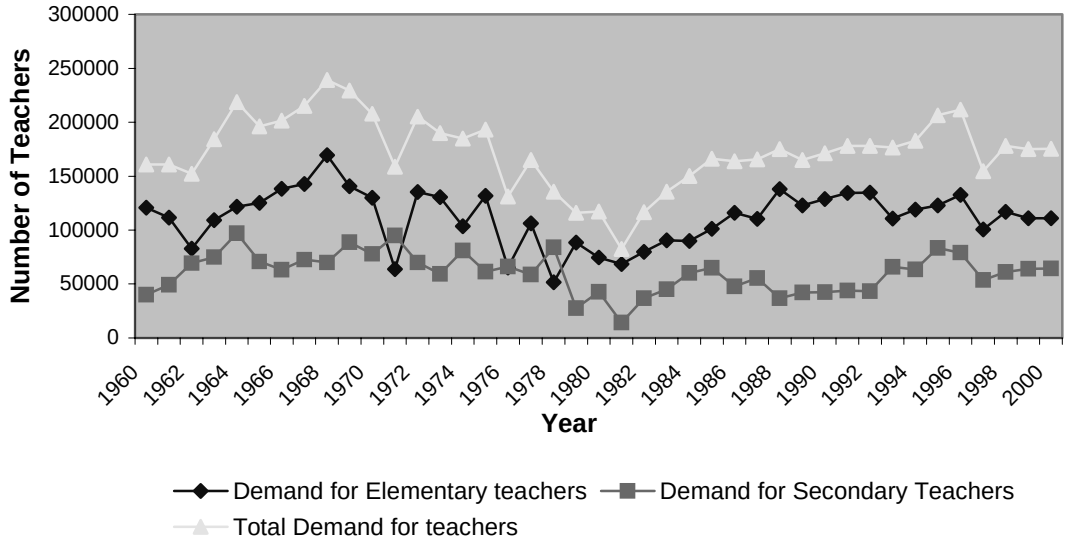
In examining the teacher supply and demand conditions in the USA, we apply a model used by Weaver (1980) who looked at the number of additional teachers required in the event of a change in 3 elements, i.e. the change in the teacher turnover rate, the change in the pupil-teacher ratio and the change in pupil enrolment. Additional demand was then derived from taking the total number of teachers required from these 3 changes.

On the supply side, Weaver's model looked at how this additional demand could be filled by new graduates and re-entrants in the profession. At this point, it would be appropriate to note

that the supply of new graduates in Weaver's model has its limitation due to the lack of data on the number of new graduates in teaching. While he was able to obtain actual numbers of new graduates in teaching for 1970 to 1980, he had to estimate the number of new graduates in teaching for his remaining years of 1980 to 1990.

Weaver used the linear extrapolation method to estimate the number of new graduates for the years 1980 to 1990. Weaver's linear extrapolation of the supply of new graduate teachers is based on the average rate of change for the previous five years of information. Therefore, if supply shows a net decline for the period 1975-1980, the 1981 supply and supplies to the subsequent years to 1990 will show a continuous decline (Weaver, 1980). We applied this same method when we extended Weaver's data set to the year 2000. The total number of additional teachers required in the USA for the period 1960 to 2000 is shown in Figure 22.

Figure 22: Additional Demand for Teachers, USA 1960-2000



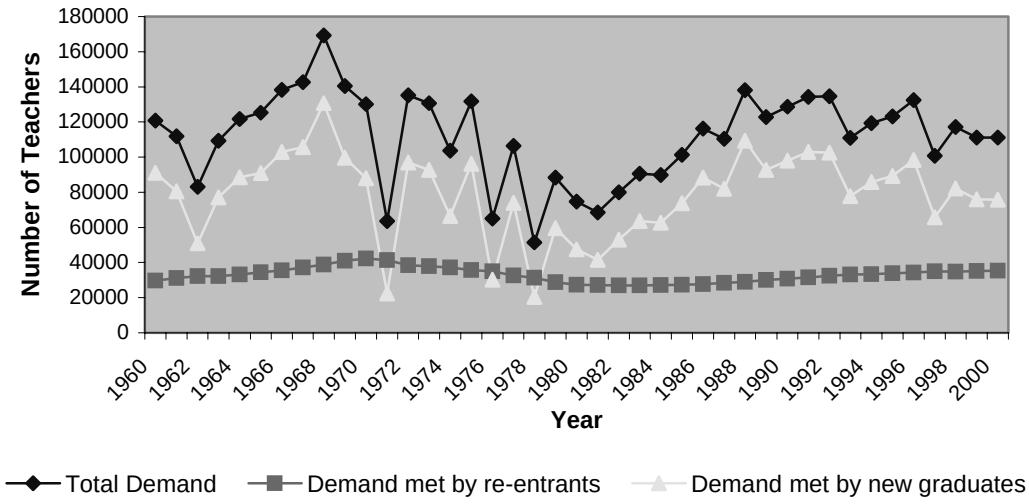
Source: Weaver (1980) and own calculations

In fulfilling the additional demand for teachers, as per Weaver's model, Figures 23 and 24 show the proportion filled in by re-entrants and by new graduates into teaching. Figure 23 shows the situation for the Elementary schooling level while in Figure 24, it depicts the Secondary schooling teacher condition. From both the graphs, new graduates appear to be the major source of teachers in filling the additional demand required by the USA teacher labour market.

In our adaptation of the Weaver teacher demand and supply model, we have applied an average re-entrance rate of 2 % for teachers in the USA based on the figures previously used

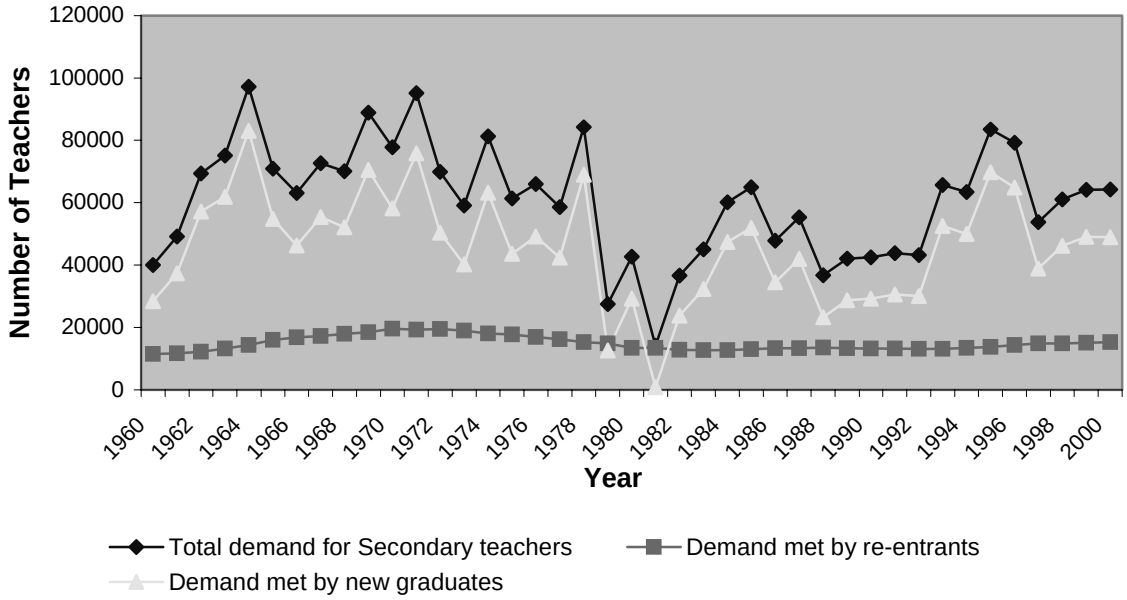
by Weaver. In Murnane *et al.* (1991), the characteristics of returnees were found to include female teachers, Elementary schooling level teachers and teachers with lower test scores.

Figure 23: Imputed Additional Demand for Elementary Teachers, USA 1960-2000



Source: Weaver (1980) and own calculations

Figure 24: Imputed Additional Demand for Secondary Teachers, USA 1960-2000



Source: Weaver (1980) and own calculations

While we do not have a trend of the number of teachers leaving in the USA, in a NCES report on the "characteristics of stayers, movers and leavers: results from the Teacher Follow-up

Survey of 1994-95", it is reported that the teacher attrition rate in public schools in the USA was 6.6 % between the 1993-94 and 1994-95 school years. For the same period, the UK teacher attrition rate was slightly higher at 8.5 %. In the USA, teachers who were likely to leave are teachers in their first years, younger woman teachers, white teachers compared to black teachers, secondary school teachers, teachers with high scores on standardized tests and teachers who were paid the least (Murnane, *et al.*, 1991). The importance of relative wages in retaining and attracting teachers into the profession has already been discussed in the literature review section and Murnane *et al.*'s findings reinforces the findings in the papers reviewed in section 7.

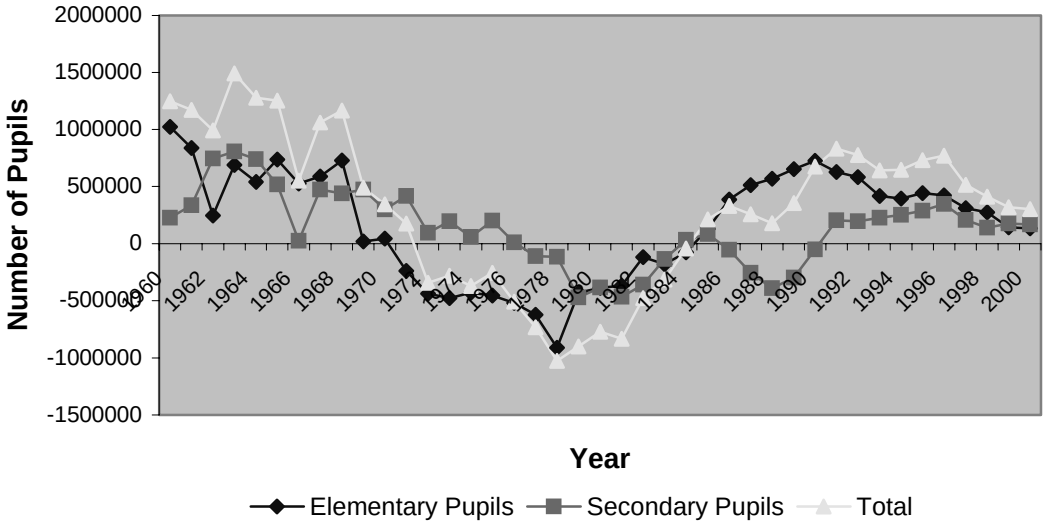
In the 1994-95 Teacher Follow-up Survey, the main reasons cited for leaving were retirement and pregnancy/child rearing. Similar to some of the reasons quoted by UK teachers, USA teachers were also leaving the profession due to dissatisfaction in the teaching conditions at school. In the NCES (1997) report, student discipline and related problems were some of the reasons given for teachers wanting to leave the profession. In a study by Smithers and Robinson (2001) for the National Union of Teachers in the UK, student discipline problems were also one of the reasons given by teachers for leaving the profession.

From the evidence, it appears that the reasons for teachers wanting to leave were mainly related to the conditions at work. At the same time, there is also evidence that indicates that relative wages do play a role in the decisions that teachers take in deciding whether to continue in their teaching career or not. The NCES (1997) reported that 53.1 % of public school teachers were of the opinion that higher salaries would be the most effective way of retaining teachers at schools. This indicates that the teacher labour market would need to be competitive enough to attract and retain teachers in the profession and this may suggest that the teacher labour market could be indirectly related to the economic cycle of the country via relative wages.

When the two elements of teacher supply and demand are interacted, the USA's teacher labour market faced a similar situation to that found in the UK. There was a surplus of teachers in the USA at about the same time as that in the UK. Between 1945 and 1969, the USA faced a shortage of teachers but surplus of teachers was experienced by the USA in the period after 1969 (Dimmock, 1980). One of the possible reasons for this surplus of teachers in the 1970s could have been due to the decreasing number of pupils enrolled during this

period. As shown in Figure 25, the pupil number declined dramatically in the 1970s, especially among the Elementary pupils. The decrease in the number of pupils enrolled would have caused the number of teachers required to decrease and hence, the condition of teacher surplus.

Figure 25: Pupil Enrolment Change, USA 1960-2000



Source: NCES

Similar to the UK, the USA teacher labour market has been facing shortages in the past two decades. The shortage of teachers in the 1980s and 1990s in the USA is not only contributed by the increasing number of pupils but is exacerbated by the fact that the teachers who were hired during the baby boom years are now on the path towards retirement. Hence, there is now a need to not only fulfil additional demand due to changing pupil-teacher ratio and pupil enrolment, there is also a need to fill the vacancies left by retiring teachers. In Hussar (2002), it is predicted that by 2008-2009, 1.7 million to 2.7 million teachers would need to be hired by public schools in the USA.

In addition to the attention paid to teacher shortages in the USA, a reasonable amount of concern has been raised in terms of teacher quality in the USA. Murnane *et al.* (1991)'s finding that teachers with higher test scores are less likely to return to teaching is reinforced in the Corcoran *et al.* (2002) study which finds that students with the highest verbal and math scores on standardized test are less likely to enter teaching.

The availability of time series data on teachers in the USA is relatively weaker than that available in the UK. However, using all possible data sources, this section has attempted to describe the teacher supply condition in the USA. While the graphs are able to give us an indication of the teacher supply and demand condition in the USA, we may need to rely on some econometric modelling to help us further understand the relationship between teacher supply in the USA and its economic cycle (See section 11).

9. The Supply of Teachers and the Economic Cycle in other Countries.

Until now we have explored the evidence relating to the different aspects of the teacher labour market in the UK and USA. In this section, we will attempt to shed light on the relationship between teachers' salaries and some economic and educational variables for most of the OECD countries and for countries, which participated in the WEI Project.[19]

It should be noted that a major difficulty in any study of this sort is the existence of heterogeneity in the educational systems of the different countries that cannot be observed. This is an inevitable shortcoming in the dataset that we have used in this section. Nevertheless an examination of this nature, i.e. using a cross-country set of data would be interesting. In such an analysis, each country would be at different points in the economic cycle and hence, any significant relationship between the variables representing teacher supply and the economic cycle in this data set would be evidence of a link between these two components.

In this data, basic characteristics of the educational system are observed (or derived) to allow us to measure educational expenditure per head as evidence of the country's investment in education, the average number of teacher hours supplied (as obviously fewer teachers can compensate for lower numbers of teacher by working more hours), the relative supply of teachers as measured by the number of teachers and the student/teacher ratio and the demand for teacher services as measured by the demographic growth in the size of the population of school age. In addition, we are able to control for the salary in primary and secondary schools, and the proportion of women teachers in the profession in each country.

[19] This project was carried out by the OECD and UNESCO, with the support of The World Bank.

To draw a general picture of the aggregate factors, which have an impact on the average teachers' salaries per hour in primary education, lower secondary education and upper secondary education, we present the findings in Table 1. Table 1 shows the results of two different specifications, obtained by using the OLS (Ordinary Least Squares) estimation method. The overall goodness of fit of these models is high (0.79 and 0.81, respectively), which means that the included variables have a high capacity to explain the variance observed in teachers' salaries in the countries sampled. Moreover, the results of the F-test indicate that the model estimated is significant at the 1 % confidence level (for both specifications).

Table 1: OLS estimation explaining the variations in teachers' salaries per hour in primary education, lower secondary education and upper secondary education[20] (1999)

	Specification I		**Specification II**	
Variables	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Constant	38.243	24.644	37.794*	21.989
Teachers and staffs (%)	5.258	3.664	4.483	3.428
Teaching hours per year	-0.016	0.015	-0.015	0.014
Women among teaching staff (%)	-0.715***	0.254	-0.698***	0.234
Lower secondary	-11.827*	6.610	-9.370	6.283
Upper secondary	-14.091	9.160	-11.858	8.527
Absolute GDP growth 1998-1999	1.399**	0.622		
GDP growth 1998-1999 (%)			0.009***	0.003
Expenditure on educational institutions as a percentage of GDP	13.417***	3.013	11.904***	2.921
Student/teacher ratio	-0.639	0.389	-0.456	0.371
Growth in the size of the population at the age of primary/lower secondary and upper secondary education (%)	-0.342	0.238	-0.285	0.218
F-statistic	10.237***		12.068***	
R-square	0.787		0.813	

Note: * coefficient significantly different from zero at 10% confidence level; ** coefficient significantly different from zero at 5% level; *** coefficient significantly different from zero at 1% level.

Two different specifications have been reported to control for the different economic and educational effects. On the one hand, in Specification I, we use the absolute growth in GDP between 1998-1999, which is a measure of how important the fluctuation in wealth is on the

[20] In the WEI, educational levels are determined according to the International Standard Classification of Education (ISCED). The lower secondary education level here refers to ISCED level 2 while for the upper secondary education level, ISCED level 3 apply. For more information pertaining to the classification of the different education levels, refer to OECD (1999).

variability of teachers' salaries. On the other hand, in Specification II, we include the percentage of growth in GDP between 1998-99. This new regressor allows us to note the importance of wealth in explaining teachers' salaries in the different countries.

Examining the variables, the percentage of women among the teaching staff has a negative impact on teachers' salaries. This may result from the possible wage discrimination that women suffer in these countries throughout the economy. Alternatively, it may be a consequence of the different career promotion aspects faced by the male and female teachers in the various countries that we examine.

Two dummy variables are used to measure the differences among teachers' salaries in the lower secondary, upper secondary and primary education levels (the latter is the reference group). These variables are negative but not significant (except for the lower secondary in Specification I). From these results, we surmise that there is a no significant difference between the teachers' salaries by level of education.

The results relating GDP growth to teachers' salaries indicate that there exist a direct and positive relationship between the wealth of a country (measured both in absolute and relative terms) and their teachers' salaries. As expected, any increase in the expenditure on educational institutions (as a percentage of GDP) has a significant and positive effect on teachers' salaries. Finally, the variables "student/teacher ratio" and the proxy of the growth in demand for education are not significant at all.

Overall, the results seem to indicate the existence of a relationship between the change in GDP and teachers' salary level, which we have used as a proxy measure of the teacher supply in the countries contained in this World Bank data set.

10. Main Results from the Econometric Modelling

In section 7 and 8, we attempted to illustrate the relationship between the various teacher supply variables and economic growth using GDP growth over time. As noted, the graphical illustration is only able to allow us to consider two variables at one time and hence, does not provide a full picture of this relationship without the consideration of the other factors which are thought to influence teacher supply (for example, graduate unemployment, trade union activities, and so on).

Given the need to bring in the interaction of the other variables, it would be appropriate to analyse the effects of the economic cycle on the supply of teachers using a time-series econometric model. Appendix B and C contains details and tables of the regression results presented in this section. For the UK, our approach is to model teacher-pupil ratio,[21] attrition rate and change in the pool of inactive teacher variables as a function of all the relevant exogenous data that we have on the labour market and education trends. The latter are important to be able to control for changes in graduate unemployment, educational and demographic quality, financial inducement and trade union density. It is only by attempting to control for all these variables that we can be sure that we have modelled the true relationship between GDP growth and other aggregate measures of the business cycle and teachers supply. It would be practical to analyse these variables for male and female teachers separately as we have seen in section 7 how each gender could have different sets of influencing factors.

Tables B7 and B8 in Appendix B detail the regression results using the teacher-pupil ratio for males and females respectively as the measurement of teacher supply. The main results from this investigation show that economic growth does not have a significant effect on the UK male teacher-pupil ratio. The other variables, i.e. male relative wages and male graduate unemployment are also insignificant, strengthening the finding that the economic cycle does not have any effect on the supply of teachers when measured by the male teacher-pupil ratio. The results remain the same when we take trade union concentration among teachers in the UK and the quality of teachers into consideration.

Similar results are obtained when we analyse the relationship between the female teacher-pupil ratio and the economic cycle. The only variable that appears to have an affect on the female teacher-pupil ratio is the fertility rate of women. As hypothesised, the higher the fertility rate among women, the lower the teacher-pupil ratio, indicating that the supply of female teachers could be affected by the decision to leave teaching to take over household responsibilities especially for childbearing purposes.

[21] The teacher-pupil ratio is used since the number of pupils must be conditioned into the supply of teachers in the economy. The idea is that this variable gives us a measure of supply, which is weighted, by how many pupils there are. Raw teacher numbers rising because pupil numbers have risen does not constitute a rising real teacher supply in terms of the average class size. Hence, what matters are how many teachers there are per pupil.

Pooling the results using the male and female teacher-pupil ratio as the supply of teacher measurement, we seem to be unable to find a significant relationship between economic growth in the UK and our teacher-pupil ratio variable, which we have used to represent the teacher supply condition in the UK. However, before a firm conclusion is made, we continue the analysis of this relationship by looking at our second teacher supply variable and this variable is the attrition rate of teachers analysed by gender.

Tables B9 and B10 in Appendix B presents the results using the attrition rates by gender. Similar factors (i.e. graduate unemployment, relative wages and so on) were considered when we analysed attrition rates as a measure of teacher supply. The results were inherent, when male attrition rates have an inverse relationship with male graduate unemployment. Male relative wages also appear to indicate a negative relationship with male attrition rate. This negative relationship can be expected given that one would have a tendency to stay on in a profession if the wages relative to another occupation increases, giving male teachers the notion that wages in the teaching profession is higher than the wages that can be obtained in another position within the non-manual work sector. There remained an insignificant relationship between real GDP growth and male teacher attrition rates.

However, when we consider teacher trade union concentration and teacher quality, real GDP growth indicates some level of importance in affecting male attrition rates. The effect is a negative effect (the higher the economic growth in the country, the lower the attrition rate). However, the magnitude of the coefficient on the real GDP growth variable is small. Hence, even though we have a negative and significant relationship between real GDP growth and male attrition rates, the overall impact that the real growth of GDP could have on the outflow of male teachers in the UK is small. In the previous section, we speculated that teachers may not find the profession as stable since our graphical analysis of the data indicated that there would appear to be a negative relationship between attrition rates and real GDP growth. We can now verify from our econometric estimation that the impact of this negative relationship is small.

While we can interpret short run effects of our independent variable on the dependent variable directly from the coefficient obtained on the variable of interest, we are also able to measure the long run effects of the independent variable on the dependent variable from our dynamic model by examining the cumulative effects of our lagged right hand side variables.

Using the results in Table B9, we can calculate the long run effects that changes in male relative wages might have on male attrition rates. In the long run, we would expect WM_{t-1} to move towards WM_t and the same to occur for relative wages, i.e. $RWM_{t-2}=RWM_{t-1}=RWM_t$ in the long run. Using these assumptions, we find that in the long run (using the results in Column (1)), male relative wages has a positive impact of 0.08 on male attrition rate. While these results seem to contradict economic theory and logical reasoning, it could also point towards the possibility that there are other important factors, which affect male attrition rates other than relative wages. One factor, which we have not considered in our analysis, is job satisfaction, which is difficult to measure quantitatively, and could be one factor that has a role to play in influencing male attrition rates over time.

The other results in Table B9 show a positive and highly significant coefficient of 0.13 on the teacher quality control variable lagged two periods. This positive coefficient indicates that the higher the proportion of school leavers with 2 A-level passes, the higher the attrition rate among male teachers. This finding could be an indication that those with higher passes or who do better in pre-university examinations and enter teaching could have a higher likelihood of leaving the teaching profession at some point in time. In the USA, this factor was found to be prevalent among the characteristics of teachers who were likely to leave the teaching profession.

The male attrition rate results suggest that there are significant relationships between the economic cycle and teacher supply in the UK. Graduate unemployment and real GDP growth appear to be influencing factors of male teacher attrition rate (with the former showing higher significance than the latter factor). However, the magnitude of the coefficient on both variables appear to be small and hence, the relationships between male graduate unemployment and male teacher attrition rates and economic growth and male teacher attrition rates could be interactions that are significant but with a low impact.

On the other hand, the female attrition rates do not appear to show many interactions between the dependent variable and the set of independent variable as compared to the results which we obtained using the male attrition rates. The only variables that seem to matter in the female attrition rate analysis are the female graduate unemployment, trade union density and the teacher quality proxy variable.

It appears that the higher trade union density there is, the lower the female teacher attrition rate – this is deduced from the negative relationship that we obtained from our regression results (See Table B10, Column (2)). We obtained similar results on the proxy for teacher quality variable. This variable has a significant and positive coefficient which signifies that the higher the proportion of female school leavers with 2 or more A-levels, the higher the female attrition rate. Such a result leads us to raise again the issue that the more able teachers are more likely to leave the teaching profession.

Having examined the male and female attrition rates, we move on to look at the link between the pool of inactive teachers and the economic cycle. As we have noted, this group of teachers are a potential source in helping to solve the teacher shortage problem in the country. Therefore, it would be deemed to be important to try to understand more about this group of teachers. We choose to use the change in the pool of inactive teachers by gender as the dependent variable as we would like to examine the flows of this variable and not its stock. We are interested in looking at the factors which would prompt teachers to enter into this pool of potential teachers and to also gauge the factors that would make them leave this pool, to seek work in the non-teaching sectors. Tables B11 and B12 in Appendix B display the results of our analysis on the changes in the pool of inactive male teachers and pool of inactive female teachers.

In Table B11, when we included all the main regressors in the analysis, the results indicate all variables are highly significant with the exception of the male graduate unemployment and the real GDP growth variables. The signs on the coefficients are as expected. Intuitively, the relationship between male relative wages and the change in the pool of inactive teachers for males indicates that the higher the relative wages for males, the lower the change in the pool of inactive teachers for males. This latter outcome confirms the finding that we obtained in our male teacher attrition regressions, where males are found to be sensitive to relative wages.

The results remain intriguing when we took into consideration the teachers' trade union density and teacher quality condition. The real GDP growth variable remains insignificant while the other variables are highly significant. The signs are also as expected with the exception of the negative sign obtained on the real GDP growth variable. The negative sign (although the variable is insignificant) on the real GDP growth variable seem to give us the

result that as GDP increases, the change in the pool of inactive male teachers decreases. Two main groups are lodged within our pool of inactive teacher figures. They are the fresh teacher graduates who do not enter teaching and the second group are those who have the qualifications, go into teaching but leave before the age of retirement. The latter group constitute the bigger sub-population of the pool, hence, with a negative relationship between real GDP growth and the change in the pool of male inactive teachers, we are driven to speculate that as the economy becomes better, more males are opting to go into alternative professions and would not consider teaching as their next occupation. The insignificance of this variable supports the findings that we have so far from using the male Teacher-Pupil ratio and the attrition of male teachers as dependent variables, i.e. there isn't a strong relationship between the economy's growth (measured by real GDP growth) and teacher supply.

Trade union density appears to have a negative and significant effect on the change in the pool of inactive male teachers. The higher the presence of trade union density among teachers, the lower the change in the pool of inactive male teachers. The proxy for male teacher quality, i.e. the proportion of male school leavers with 2 or more A-levels appears to indicate a positive relationship with the change in the pool of inactive male teachers. The relationship between these two elements is significant at the 1 % level and we are drawn to conclude that higher quality teachers do have a higher likelihood of leaving the teaching profession at some point in time as we had deduced based on the male attrition rate results discussed in an earlier paragraph of this section.

In the female pool of inactive teacher regressions, only relative wages matter among the teachers in the pool of inactive teachers. The female relative wages variable is found to be highly significant and this relationship is one where the higher the relative wages, the lower the change in pool of inactive female teachers. This indicates that if female teachers are paid higher wages, they are likely to be in teaching. The other variables are not significant, hence, not allowing us to report any relationship between economic growth (measured by real GDP growth) and/or graduate unemployment and the change in the pool of inactive teachers for females. When we include trade union density and our proxy variable for teacher quality, the results do not change, since the relative wage variable remains as the only significant regressor variable among the main variables under investigation.

To investigate the relationship between the supply of teachers and the economic cycle in the USA, we utilise a similar model as that applied to the UK data, i.e. an autoregressive distributed lag model. The results are displayed in Table C6 in Appendix C.

The results that we obtain appear to reflect the findings as reported by Berman and Pfleeger (1997) in the USA. Recalling this study, it was reported that the teacher market in the USA was not affected by the USA economic cycle. Regardless of the model specification, we are unable to detect any significant relationship between real GDP growth and the teacher supply measured using the USA's teacher-pupil ratio from the results presented in Table 19. Even when we use the other indicator of the condition of the economy in the USA, i.e. graduate unemployment, we fail to obtain a significant sign and coefficient on this variable. This therefore does not allow us to report any link between graduate unemployment and teacher-pupil ratio.

The only variable which our regression results appear to exhibit as significant is the relative wages variable. However, the sign on this variable is counter intuitive. The results show a negative relationship between relative wages and the teacher-pupil ratio. This negative sign is interpreted as the higher teachers' relative wages, the lower the teacher-pupil ratio, which does not accord with economic theory.

The sample size of this variable is small whereby we were only able to analyse 34 years of this data (in the unit root test and 29 years of data in the full regression). The discrepancy in the sign on this variable could also have been caused by the small sample size that we are faced with. Another factor that might have driven this counterintuitive result that we have obtained between relative wages in the USA (RW_USA) and Teacher-Pupil ratio (TPRTOT) is the fact that the teacher labour market in the USA is considerably different from that in the UK. In the USA, the teacher labour market is of a heterogenous nature, given that each State carries their own legislation pertaining to teachers. According to the Education Intelligence Agency, political forces and not market forces chiefly determine public school teacher compensation in the USA. They go on to note that: -

> "Differences in salaries from state to state are determined by the status of the economy, collective bargaining laws, and the mood of the public. Differences from district to district are usually determined by the tax base and the relative skill of the district and union negotiators at the bargaining table"

Education Intelligence Agency, http://www.calnews.com/Archives/1YB_II_sal.htm

By having used aggregated data, we would not have been able to capture the heterogeneity that occurs in the USA teacher labour market, which we suspect might have a role to play in our counterintuitive results.

11. Conclusion

The main investigation in this paper is to examine if the economic cycle has any effect on the supply of teachers. In this paper, we have been able to summarize the available literature on the relationship between teacher supply and the economic cycle. It is reasonable to conclude that this literature is fairly small and relatively inconclusive. In order to clarify the relationship between teacher supply and the economic cycle it was necessary to:

- Define how the presence of an economic cycle can be measured and empirically tested.
- Show how the teacher labour market could theoretically be affected by the economic cycle. By doing this, we are able to set out a clear model of the way the teacher labour market functions.
- Clarify what the notion of the supply of teachers is and how to measure it empirically.
- Collect data relating to at least one country over time to facilitate estimation of the underlying relationships.
- To make sure that for the same country there is sufficient controlling data to condition for education, labour market and demographic changes.
- Examine the stationarity properties of the time series data collected.
- Specify and estimate an econometric model of what influences teachers supply and how it relates to economic cycles.

We fitted our data into an autoregressive distributive lag model, which is a dynamic model that has allowed us to have some empirical understanding of the relationship between teacher supply and the economic cycle in the UK and the USA. Our measure of teacher supply in the econometric modelling included teacher-pupil ratio, attrition rates and the pool of inactive teachers for the UK and teacher-pupil ratio for the USA. In the UK case, we have examined each variable separately by gender.

For the UK, the following results were obtained.

- There were no significant relationships between teacher supply measured by teacher-pupil ratio and the economic cycle, as measured by real GDP growth. The results were the same for both males and females.
- Fertility was the only significant variable in the female teacher-pupil ratio equation.
- Real GDP growth and male graduate unemployment have a significant but low impact on male attrition rate while no such relationship was found in the female attrition rate regression results.
- There is time series evidence to show that males are more sensitive to relative wages compared to females, which supports the cross section evidence available.
- Consistent results were obtained by regressing the change in the pool of inactive teachers for males with our set of independent variables. The change in the number of male teachers in the pool of inactive teachers is significantly influenced by male graduate unemployment (when controls for trade union density and teacher quality are considered), relative wages and trade union density. All three variables were negatively related to the change in the pool of inactive teachers for males (DPITM).
- In the female regression using the change in the pool of inactive FEMALE teachers as the measure of teacher supply, we were only able to find a significant negative relationship between relative wages and the change in the pool of inactive female teachers.
- We also find some evidence that educational quality improvements could have a negative impact on teacher supply. The proxy variable for teacher quality (lagged two periods) was significant and positive in a number of our regressions, namely, in the male and female attrition regressions, in addition to the change in the pool of inactive teachers for males. The positive sign seem to point towards the higher likelihood of teachers with better examination results leaving the teaching profession.

The findings were robust to attempts using a different measure of the economic cycle. Results were similar when we replaced the real GDP growth variable with a dummy variable constructed to measure the expansionary and contractionary periods in the UK economy. The results summarised above were derived from regressions where we were able to include controls for trade union density, educational quality and other education-demographic variables. So far, we do not know of another study that has been able to do this using a set of time series data.

Using data collected mainly from the NCES publications, the results for the USA appear to reflect the findings in the Bureau of Labor Statistic's (Berman and Pfleeger, 1997) study on "Which Industries are Sensitive to Business Cycles". In the USA regression, there was no significant variable that we were able to tie in with our measure of teacher supply in the USA, i.e. teacher-pupil ratio. Although relative wages between teachers and other employees working full-time in the USA is significant, the sign that we obtain is counterintuitive. We think that this wrong sign could have been attributed to some level of heterogeneity in the teacher labour market in the USA where each state is very different. In addition it must be remembered that analysis is confined to aggregate data with a small sample size.

We have also made an attempt to understand the relationship between the supply of teachers and the economic cycle in the other countries by using the World Education Indicators (WEI) data set. Drawing on the 1999 data set, we were able to find a relationship between the change in GDP and the level of teachers' salary in the participating WEI countries.

A major limitation of this study was the availability of data. This prevented us from being able to include teachers from the different schooling sectors (i.e. primary and secondary levels in the UK and the elementary and secondary levels in the USA), in addition to being unable to examine this issue by regions and subjects where the shortage of teachers are most prevalent. Future work should consider these limitations to enhance our understanding of the effects of economic growth on the supply of teachers.

It would also be interesting to re-visit these results with a longer time series data set and to see if these findings can be replicated. For now, we seem to have found evidence of a relationship between teacher supply and the economic cycle and the evidence shows that it works through relative wages and unemployment changes rather than through real GDP growth per se. Relative wages appear to remain as an important factor affecting the teacher labour market in the UK, specifically when we distinguish between the market for male and female teachers. The time series analysis that we have undertaken appears to be able to confirm results from existing cross section data analysis on the teacher labour market, both in the UK and the USA. Notwithstanding the caveats in this study, the policy implication of this study seem to point towards using relative wages as a tool to improve the teacher shortage situation. Policy makers should also be reminded of the fact that there are differences between the different markets for teachers, i.e. primary and secondary; male and female

teachers (as this study has shown) and between teachers of different subjects in secondary schools.[22]

[22] See Dolton, 1996

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Appendix A: Measuring and Testing for the Presence of Cycles.

The single series most commonly held to represent the business cycle is real GDP. The methods originally proposed were non-parametric and sought to identify cycles by finding the turning points in a series. Subsequent to the early work cited above, academic research has developed along quantitative, or parametric lines where models for the cycle are analyzed. Prominent among works of the latter type are Cooley and Prescott (1995) and Hamilton (1989).

More recently, Harding and Pagan (2001a, 2002) have compared and contrasted the two approaches and argued that the dating of cycles can be approached using their criteria of "transparency, robustness, simplicity and replicability" (Harding and Pagan, 2001a, Section 1) using the Bry and Boschan (1971) algorithm. This works by seeking to identify turning points in a series and then using these to document expansions and contractions in an economy.

The Bry and Boschan (1971) algorithm was introduced for use in the context of monthly data. Harding and Pagan (2002) adapt the procedure for use with quarterly data. Our data set is primarily annual, but we carry out a preliminary analysis using quarterly GDP with a view to establishing those years where the national economy of a country can be reasonably regarded as being in expansion or contraction. This is likely to be an important determinant of the dynamics of the labour market for teachers.

The assessment is best carried out on the levels of a series without detrending or filtering. As argued in Harding and Pagan (2001b), the Real Business Cycle literature shows that the permanent component of any variable whose cyclical behaviour is being analyzed is a major cause of the business cycle. Hence its removal (by detrending, or other means) will mean that the cycle is no longer under examination; the arguments of Harding and Pagan (2001b, Section 2.1) indicate that turning points in such filtered series can be very different from those in levels thereof.

The procedure essentially indicates the presence of a turning point in a series as follows:

a peak in the series occurs at time *t* if

$$y_t > y_{t-1}, y_{t-2} \text{ and } y_t > y_{t+1}, y_{t+2};$$

and a trough in the series occurs if

$$y_t < y_{t-1}, y_{t-2} \text{ and } y_t < y_{t+1}, y_{t+2}.$$

In practice some extra requirements need to be made of the algorithm to rule out spurious turning points. By this we essentially mean censoring rules to avoid cycles of insufficient length or amplitude and a procedure for ensuring that peaks and troughs alternate.

The results of Harding and Pagan (2001a, Table 1) show that this deceptively simple procedure is able to date the US business cycle via the turning points in real GDP in a manner almost indistinguishable from the NBER method.

The adaptation of the censoring rules of Bry and Boschan (1971) to the case of quarterly data is not without difficulty. In analyzing UK real GDP we adopted the rule of deeming a 15 month cycle (the minimum length of a complete cycle) to be consistent with a four quarter minimum length. This parallels the work of Harding and Pagan (2002) and allows identification of the 1974 cycle; with a five quarter rule this would be ignored.

Having used the algorithm to determine the turning points at the peaks and troughs of the cycle, the information is used to determine, in the context of the annual data forming the body of the analysis, which years can be considered to be expansionary in the national economy and which contractionary. The rule we used for this was to deem a year to be contractionary if two or more quarters in a given year lie between a peak and a trough. Otherwise the year is deemed expansionary. This facilitates the construction of a dummy variable S_t taking the value unity if a year is expansionary and zero otherwise.

Appendix B: Econometric Modelling - UK Results

This section details the econometric work undertaken to derive the UK results on the effect pf the economic cycle on the supply of teachers.

As we have a time series data set, we would firstly need to assess the integration properties of the data. The data needs to be stationary or I(0) to avoid the possibility of obtaining regression results that are spurious or misleading. In order to test for stationarity, we will apply the Augmented Dicky Fuller (ADF) test on each of the variables in our dataset. The general ADF(*p*) regression with a drift parameter that we will be applying is as follows:

$$\Delta Y_t = \mu + \gamma Y_{t-1} + \sum_{j=1}^{p} \alpha_j \Delta Y_{t-j} + \varepsilon_t$$

The coefficient of interest in the above regression is γ and our null hypothesis (H_0) is that $\gamma=0$ indicating that the time series has a unit root and $\gamma<0$ in the alternative hypothesis (H_1). If the null hypothesis is rejected, we can conclude that our variable does not evidence a unit root as part of its time series properties. The above equation can be augmented to include a linear trend (t) (indicating a quadratic trend in the data in levels) variable to give the following equation: -

$$\Delta Y_t = \mu + \gamma Y_{t-1} + \sum_{j=1}^{p} \alpha_j \Delta Y_{t-j} + \beta t + \varepsilon_t$$

The testing of the presence of unit root in our time series data will be further explained in the next section as we present the test results for our dependent variables. After we have determined the integration properties of the data, the appropriate decision can be made about how the regression analyses should be proceeded with. It is imperative that any non-stationary I(1) variables are not regressed against variables which seem to be stationary.

The regression results will be tested using the usual time series diagnostic tests, consisting of tests for serial correlation, heteroskedasticity and functional form. Again, these tests will determine if the results that we obtain are data coherent and to avoid the use of invalid inference procedures.

Investigating the integration properties of teacher-pupil ratios, teacher attrition and the change in the pool of inactive teachers in the UK dataset.

The six variables that we seek to explain in this analysis are: teacher-pupil ratios; and teacher attrition rates, each subdivided into males and females. As indicated above, it is important to try to determine whether these variables over the period for which data is available (viz. approximately 1960-2000 on an annual basis) have time series properties that indicate the presence of a unit root (stochastic trend) or not. In the absence of a stochastic trend, any series may exhibit stationary fluctuations about a deterministic trend. Of course, in reality, few socio-economic variables can exhibit deterministic trends over very long periods, but the use of such components to satisfactorily model variables over the time period for which observations are available may nevertheless be required.

Inspection of a time series plot of the six variables of concern suggests that it is necessary to consider the breakdown of both teacher-pupil ratios, attrition rates and changes in the PIT into male and female components. For instance, although the teacher-pupil ratios exhibit similar plots for males and females, the level of the male teacher-pupil ratio (TPRM) is invariably higher than that for females (TPRF). It is also evident from the plots of these two variables that the ratios reached a peak in the late 1980s and have since declined steadily; this may be evidence of a structural break in the series.

Turning to the attrition rates it is clear that, over the 40 years or so for which data are available, attrition rates have consistently varied in the range 7-10% per annum for women (WF), whereas the comparable figures for men (WM) have systematically increased from just over 2% to around 7 or 8% in recent years.

Figure B1: Teacher-Pupil Ratio in the UK, 1947-2000

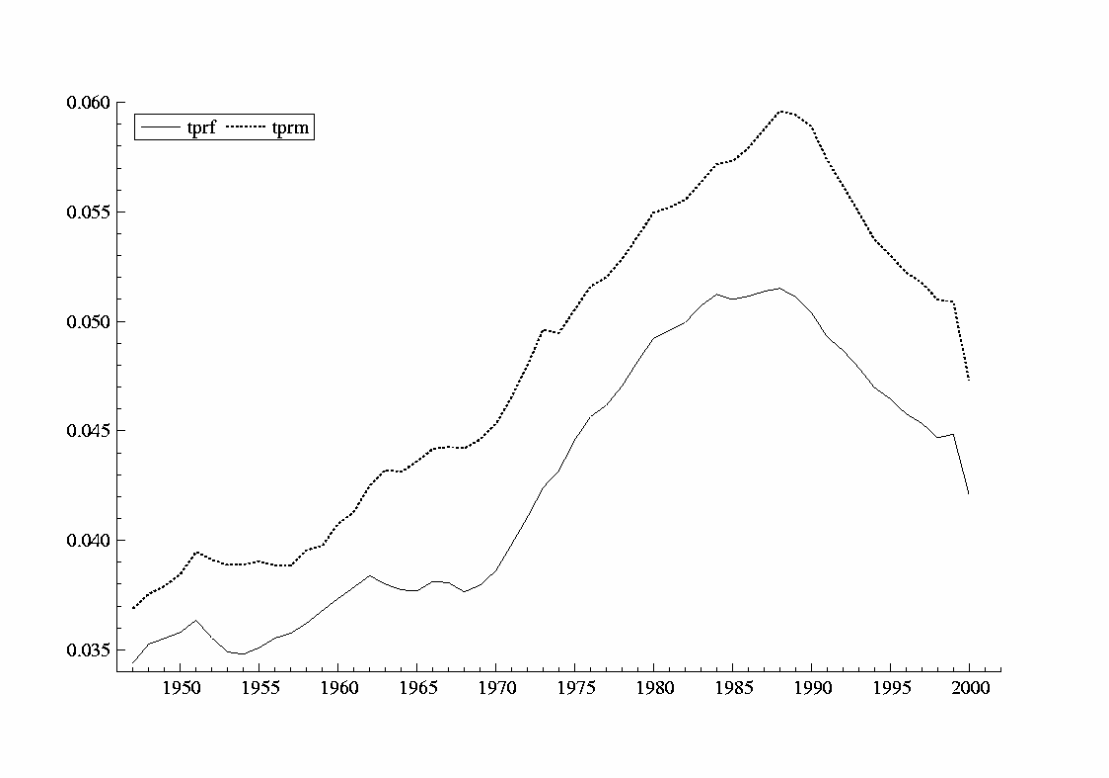
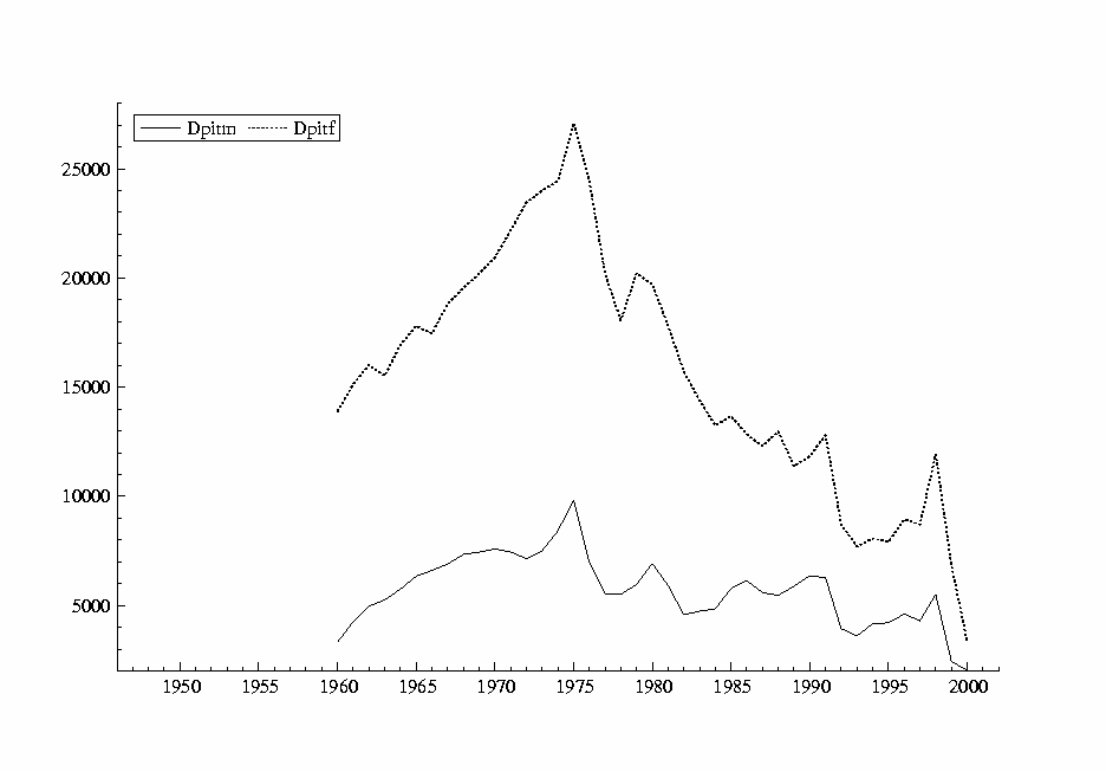


Figure B2: Male and Female Attrition Rates in the UK, 1959-2000

The trend of the male PIT and female PIT we previously presented in Figure 15 show an upward trend with a decreasing change over the years. The latter can be seen in the change in PIT trend displayed in Figure 28 in the main text.

Figure B3: The change in the Pool of Inactive Male and Female Teachers in the UK, 1960-2000



Although the application of unit root tests to help determine the presence of a stochastic trend (the null hypothesis of a unit root cannot be rejected on the basis of the data) is now routine, particularly in macro econometrics, there are a number of pitfalls in the application of such tests. Firstly, it is well known that it can often be very difficult to distinguish between a unit root and a stationary autoregression about a deterministic trend with a coefficient of, say, 0.85 or greater. This difficulty arises from questions relating to the poor power properties of standard testing procedures in this situation. Second, all statistical theory in this area is based upon asymptotic considerations and there is always the question of just how reliable this is as a guide to the true, but unknown, finite sample distribution of the test statistic being employed in the context of the sample size available. Note here that we are operating with a maximum of no more than 40 observations, rendering strong adherence to the results of asymptotic theory at best open to question.

Finally, the presence of deterministic components in any specification being used to test for unit roots has non-trivial implications. For instance, an Augmented Dickey-Fuller specification being used to test for a unit root 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. At the margin, it may often be unclear which is the more suitable to use. Finally, problems associated with a paucity of data may, anyway, impinge on the reliability of the asymptotic results which have been appealed to.

Adopting the Augmented Dickey-Fuller approach to testing for a unit root in the teacher-pupil ratio series for males (based on 38 annual observations from 1963 to 2000) and mindful of the potential structural break, we fit Model C of Perron (1989) to allow for a break in both drift and trend parameters in 1989. We find that allowing augmentation of the Dickey-Fuller regression with two additional lags produces residuals with no evident autocorrelation. This is assessed using a Lagrange Multiplier test for AR(2) errors. The results, as presented in Table B1 are indicative of a model with highly significant constant and linear trend parameters.

Both dummy variables for the presence of a structural break are also highly significant at conventional significance levels. This leads us to assess the evidence for a unit root based on the coefficient of the lagged value of the male teacher-pupil ratio (TPRM_1) using the standard normal distribution. The hypothesis of a unit root can be convincingly rejected at conventional significance levels (it has a one-sided prob-value, or marginal significance level, of 0.002). We feel that this series may be gainfully modelled as exhibiting stationary variation about a breaking deterministic trend.

A similar approach to testing for a unit root in the female teacher-pupil ratio series produces analogous results, including an absence of serial correlation in the residuals from the ADF regression and a prob-value for the relevant test statistic of 0.003. The unit root test results for the female teacher-pupil ratio are presented in Table B2 below.

Table B1: Unit Root test results, Male Teacher-Pupil ratio (TPRM)

Variable	*Coefficient*	*T-statistics [prob-values]*
Constant	0.0139	3.17 [0.003]***
Trend	0.0003	3.18 [0.003]***
Break in drift	0.0346	3.27 [0.003]***
Break in Trend	-0.0008	-3.42 [0.002]***
Male Teacher-Pupil Ratio lagged one period (TPRM_1)	-0.4719	-3.11 [0.004]***
Change in male Teacher-Pupil ratio lagged one period (DTPRM_1)	0.1598	0.790 [0.436]
Change in male Teacher-Pupil ratio lagged two periods (DTPRM_2)	0.1557	0.740 [0.495]
No of obs: 38 R-square = 0.726 F(6, 31) = 13.71 [0.000]*** AR(2) test: F(2,29) = 1.2034 [0.3147]		

*** Significant at the 1 % level

Table B2: Unit Root test results, Female Teacher-Pupil ratio (TPRF)

Variable	*Coefficient*	*T-statistics [prob-values]*
Constant	0.0060	2.98 [0.006]***
Trend	0.0002	2.98 [0.006]***
Break in drift	0.0148	2.93 [0.006]***
Break in Trend	-0.0004	-3.11 [0.004]***
Female Teacher-Pupil Ratio lagged one period (TPRF_1)	-0.2480	-2.98 [0.006]***
Change in female Teacher-Pupil ratio lagged one period (DTPRF_1)	0.2074	0.908 [0.371]
Change in female Teacher-Pupil ratio lagged two periods (DTPRF_2)	0.3524	1.440 [0.159]
No of obs: 38 R-square = 0.678 F(6, 31) = 10.89 [0.000]*** AR(2) test: F(2,29) = 0.4396 [0.6485]		

*** Significant at the 1 % level

Data on attrition rates is available for a similar span, though there is no evidence of structural breaks here. In the case of female attrition we find an ADF equation with two augmentation lags is sufficient to leave no evidence of autocorrelation in the residuals of the test regression. A constant or drift parameter has a prob-value of around 0.11 and so it is difficult to be

unambiguous about its significance. If this is taken to be important in the fitted regression (so that the t-statistic on the lagged value of female attrition in the fitted regression is treated as coming from the standard distribution) the prob-value for a one-sided test of the hypothesis that the true coefficient is zero is 0.049. It is clear that there is no decisive inference here, but this limited evidence (augmented by other informal checks, such as plots of the autocorrelation structure of the data) leads us to believe that, on balance, this variable should be treated as stationary. Results of the unit root test for female attritions are displayed in Table B3.

In the case of the male attrition rates (results are given in Table B4), a similar picture emerges although, as might be expected, a fitted deterministic trend is involved. The constant and trend now have prob-values in the region of 0.12 and the test variable one of 0.02, conditional on the deterministic components being taken as non-zero. Again our inclination is to treat this variable as stationary about the deterministic trend. On this interpretation of the results, thus far, permit all four variables to be treated in a similar framework and obviate the need to consider cointegration methodology with its attendant difficulties in both small samples and in the potential presence of structural breaks.

Table B3: Unit Root test results, Female Attrition rate (WF)

Variable	***Coefficient***	***T-statistics [prob-values]***
Constant	0.0214	1.66 [0.107]
Female attrition rate lagged one period (WF_1)	-0.2379	-1.70 [0.098]
Change in female attrition rate lagged one period (DWF_1)	0.2215	1.22 [0.232]
Change in female attrition rate lagged two periods (DWF_2)	-0.0779	-0.407 [0.687]
No of obs: 38 R-square = 0.108 F(3, 34) = 1.372 [0.268] AR(2) test: F(2,32) = 1.1683 [0.3238]		

Table B4: Unit Root test results, Male Attrition rate (WM)

Variable	*Coefficient*	*T-statistics [prob-values]*
Constant	0.0075	1.60 [0.119]
Trend	0.0002	1.51 [0.141]
Male attrition rate lagged one period (WM_1)	-0.3150	-2.14 [0.040]**
Change in male attrition rate lagged one period (DWM_1)	0.1263	0.717[0.478]
Change in male attrition rate lagged two periods (DWM_2)	-0.0819	-0.398 [0.693]
No of obs: 38 R-square = 0.177 F(3, 33) = 1.652 [0.185] AR(2) test: F(2,31) = 1.0681 [0.3560]		

** Significant at the 10 % level

In testing the third variable of interest, the male and female PITs, Tables B5 and B6 display the results, which we obtained from the ADF regressions.

Table B5: Unit Root test results, Pool of Inactive Male Teachers (PITM)

Variable	*Coefficient*	*T-statistics [prob-values]*
Constant	3455.94	5.93 [0.000]***
Trend	-65.6172	-0.401 [0.691]
Pool of inactive male teachers lagged one period (PITM_1)	0.0044	0.166 [0.869]
Change in the pool of inactive male teachers lagged one period (DPITM_1)	0.6924	5.93 [0.000]***
No of obs: 40 R-square = 0.690 F(3,36) = 26.67 [0.000]*** AR(2) test: F(2,34) =1.6451 [0.2080]		

*** Significant at the 1 % level

From the ADF regression results in Table B5, 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. Table B6 below presents the unit root test results for PITF.

Table B6: Unit Root test results, Pool of Inactive Female Teachers (PITF)

Variable	*Coefficient*	*T-statistics [prob-values]*
Constant	4287.53	1.08 [0.286]
Trend	-49.0734	-0.245 [0.808]
Pool of inactive female teachers lagged one period (PITF_1)	-0.0025	-0.224 [0.824]
Change in the pool of inactive female teachers lagged one period (DPITF_1)	0.8779	10.7 [0.000]***
No of obs: 40 R-square = 0.913 F(3,36) = 125.6 [0.000]** AR(2) test: F(2,34) =1.6184 [0.2131]		

*** Significant at the 1 % level

While we are able to treat TPRM, TPRF, WM and WF as stationary variables, the contrary is found for PITM and PITF. The latter two variables display non-stationary properties or in similar terms, we find PITM and PITF to be I(1) in nature. However, our intention is not to use the PITM and PITF as our dependent variable since we are interested in investigating the influences that the economic cycle might have on the changes to these variables. Though the PITM and PITF are non-stationary, the evidence is clear that the differences in these variables can be treated as stationary, as it is these that we model. Hence, for none of the variables that we shall model, do we have to consider cointegration methodology.

Using the same approach, we tested the other regressor variables of interest and find that they can be taken to be stationary and that we maintain our contention that we need not consider cointegration in our regressions using the UK data of interest.

The Estimates and Results using the UK dataset.

We estimate our six left hand side variables in a dynamic model as follows: -

TPRM = f(GDP95, UGM, RWM, TUD, LQ2AM)

TPRF = f(GDP95, UGF, RWF, FER, TUD, LQ2AF)

WM = f(GDP95, UGM, LRWM, TUD LQ2AM)

WF = f(GDP95, UGF, LRWF, LFER, TUD, LQ2AF)

DPITM = f(GDP95, UGM, LRWM, TUD LQ2AM)

DPITF= f(GDP95, UGF, LRWF, LFER, TUD, LQ2AF)

The right hand side variables are defined as: -

GDP95 is the real GDP growth (deflated using the GDP Deflator 1995=100);

UGM and *UGF* are graduate unemployment for males and females respectively;

RWM and *RWF* are male and female relative wages;

Q2AM and *Q2AF* are the male and female proportion of school leavers with 2 A-level passes. These variables are proxy measures of teacher quality and quality of potential teachers. The lag values of these variables are used to allow for the possible delayed effect on the dependent variable,

TUD is the measure of trade union density among teachers in the UK,

FER is a proxy measure of fertility amongst women in the UK. In the female attrition and pool of inactive teacher equations, we have used fertility rate lagged one period. This is to take into consideration that the decision to leave a job occurs after child bearing.

L represents a lag operator of the individual variables and D represents the usage of the change in the data.

The data appendix details the source and measurement of all variables that are available in our data set.

From the unit root test results, we fitted the UK data into an autoregressive distributive lag model using the ordinary least squares (OLS) estimation method. Table B7 presents the results of our estimated model using TPRM as the dependent variable while Table B8 displays the modelling estimation for TPRF as the dependent variable.

Due to the presence of a structural break in our TPRM time series data, we have included the two dummy variables, which allows for a break in the drift and trend of our TPRM data series. These dummies are similar to the ones, which we used when we tested our data for the presence of unit root. The results show the structural break dummies to be significant in all our three specification (at the 10 % significant level in Column (1) and at the 1 % significant level in Columns (2) and (3)).

Other than the structural break dummy, in Column (1) of Table B7, we present the results using all the independent variables except TUD and Q2AM_2 while in Column (2), the results were obtained by including our measure of trade union density (TUD) and our proxy measure for teacher quality (Q2AM_2). Column (3) shows the result of a model, which

includes a lagged value of relative wages, as we wanted to examine the possibility of relative wages having a delayed effect on male teacher-pupil ratio in the UK.

Table B7: Modelling Male Teacher-Pupil ratio (TPRM) using Ordinary Least Squares Estimation

Independent variable	***(1)***	***(2)***	***(3)***
Constant	0.0105**	0.0209***	0.0205***
	(2.38)	(3.53)	(3.36)
Trend	0.0002*	0.0005***	0.0005***
	(1.80)	(3.08)	(3.57)
Break in drift	0.0231**	0.0406***	0.0434***
	(2.14)	(3.16)	(3.48)
Break in trend	-0.0006**	-0.0010***	-0.0010***
	(-2.25)	(-3.24)	(-3.58)
Male Teacher-Pupil ratio lagged one period (TPRM_1)	0.7039***	0.4030**	0.3464**
	(4.63)	(2.14)	(1.88)
Real GDP growth (GDP95) divided by 100,000	3.9473	4.1920	2.9217
	(0.682)	(0.766)	(0.562)
Male relative wages (RWM)	-0.0011	-0.0001	
	(-0.453)	(-0.0513)	
Male relative wages lagged two periods (RWM_2)			0.0022
			(0.881)
Male graduate unemployment (UGM) divided by 100,000	-0.6720	1.4887	0.6561
	(-0.158)	(0.321)	(0.140)
Trade Union Density (TUD)		-0.0019*	-0.0026*
		(1.73)	(-1.99)
Proportion of male school leavers with 2 or more A-level passes lagged two periods (Q2AM_2)		-0.0105*	-0.0102*
		(-2.00)	(-1.91)
No of obs.	41	41	39
R-square	0.99	0.99	0.99
AR(2) test	F(2,31)=0.41988	F(2,29)=0.21362	F(2,27)=0.38110

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

In the modelling of the female teacher-pupil ratio (TPRF) variable, we use the same variables that we used for the male teacher-pupil ratio modelling and an additional variable, FER_1, the female fertility rate variable lagged one period. Table B8 presents the results of our female teacher-pupil ratio modelling estimation. The layout of the table of results for the female teacher-pupil ratio is as per Table B7.

Table B8: Modelling Female Teacher-Pupil ratio (TPRF) using the Ordinary Least Squares Estimation

Independent variable	***(1)***	***(2)***	***(3)***
Constant	0.0140*** (4.02)	0.0142*** (3.92)	0.0150*** (3.35)
Trend	5.0371 (0.732)	7.1924 (0.792)	9.0212 (1.09)
Break in drift	0.0112* (1.99)	0.0114* (1.77)	0.0130** (2.15)
Break in Trend	-0.003** (-2.10)	-0.0003* (-1.88)	-0.0003** (-2.32)
Female Teacher-Pupil ratio lagged one period (TPRF_1)	0.7879*** (8.66)	0.7733*** (7.63)	0.7448*** (8.53)
Real GDP growth (GDP95) divided by 100,000	-0.6267 (-0.137)	-0.7282 (-0.149)	-1.5977 (-0.325)
Female relative wages (RWF)	-0.0015 (-0.900)	-0.0013 (-0.686)	
Female relative wages lagged two periods (RWF_2)			-0.0015 (-0.640)
Female graduate unemployment (UGF) divided by 100,000	0.8763 (0.225)	0.5734 (0.120)	1.0829 (0.210)
Fertility rates (FER) divided by 100,000	-4.7553** (-2.35)	-4.7407** (-2.19)	-4.2249 (-1.33)
Trade Union density (TUD)		-0.0003 (-0.254)	-0.0002 (-0.165)
Proportion of female school leavers with 2 or more A-level passes lagged two periods (Q2AF_2)		-0.0010 (-0.285)	-0.0017 (-0.458)
No of obs.	41	41	39
R-square	0.99	0.99	0.99
AR(2) test	F(2,30)=0.64663	F(2,28)=0.73041	F(2,26)=0.34184

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

The two dummy variables representing the structural break in the TPRF data series are significant as that found in the male teacher-pupil ratio models. With regard to the main variables of investigation, our female teacher-pupil ratio seem to show weaker results in terms of the signs on the coefficient attached to the variables of interest. We have a negative sign on the GDP95 and RWF variables in all the three models as presented in Table B8. In addition to having the unexpected sign, the variables are insignificant. An insignificant effect is also obtained between female graduate unemployment and female teacher-pupil ratio.

Fertility as expected, has a negative relationship with our female teacher-pupil ratio (the higher the fertility rate, the lower the female teacher-pupil ratio as more teachers leave the teacher labour market for child bearing purposes). The results do not change when we include the controls for trade union activities (TUD) and teacher quality (Q2AF_2) variables into the equation, as presented in Column (2) of Table B8. *Ceteris paribus*, these two additional variables are negatively related to the female teacher-pupil ratio and are also insignificant.

Table B9 presents the results of the autoregressive distributive lag model that we applied with male attrition rate (WM) as the dependent variable. In the first column, we only have the main variables of investigation as the regressor while in Column (2), we include the usual control variables for trade union density and teacher quality.

Table B9: Modelling Attrition of Male Teachers (WM) using the Ordinary Least Squares Estimation

Independent variable	***(1)***	***(2)***
Constant	-0.0201 (-0.731)	-0.0349 (-1.23)
Trend	0.0007*** (3.15)	0.0006** (2.22)
Male attrition rate lagged one period (WM_1)	0.6851*** (6.33)	0.5868*** (4.53)
Male graduate unemployment (UGM)	-0.0010** (-2.33)	-0.0017*** (-4.05)
Male relative wages (RWM)	-0.0608** (-2.36)	-0.0502** (-2.23)
Male relative wages lagged one period (RWM_1)	0.0547* (1.83)	0.0486* (1.78)
Male relative wages lagged two periods (RWM_2)	0.0321 (1.27)	0.0424* (1.77)
Real GDP growth (GDP95)	-0.0006 (-1.02)	-0.0009* (1.72)
Trade union density (TUD)		-0.0042 (-0.520)
Proportion of male school leavers with 2 or more A-level passes lagged two periods (Q2AM_2)		0.1309*** (3.42)
No of obs.	38	38
R-square	0.84	0.89
AR(2) test	F(2,28)=0.016882	F(2,26)=0.45149

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

Table B10 displays the results using female teacher attrition rates as the dependent variable. The layout of the table is as per Table B9.

Table B10: Modelling Attrition of Female Teachers (WF) using the Ordinary Least Squares Estimation

Independent variable	***(1)***	***(2)***
Constant	0.0358* (1.84)	0.0568** (2.38)
Female attrition rate lagged one period (WF_1)	0.5360*** (3.77)	0.3771** (2.20)
Female graduate unemployment (UGF)	-0.0007 (-1.33)	-0.0011* (-1.86)
Female relative wages (RWF)	-0.0287 (-1.31)	-0.0314 (-1.54)
Female relative wages lagged one period (RWF_1)	0.0065 (0.262)	-0.0008 (-0.034)
Female relative wages lagged two periods (RWF_2)	0.0327 (1.45)	0.0380 (1.62)
Real GDP growth (GDP95)	-0.0007 (-1.25)	-0.0008 (-1.49)
Fertility rate lagged one period (FER_1)		0.0002 (0.784)
Trade union density (TUD)		-0.0162*** (-2.77)
Proportion of female school leavers with 2 or more A-level passes lagged two periods (Q2AF_2)		0.0706** (2.09)
No of obs.	38	38
R-square	0.71	0.78
AR(2) test	F(2,29)=1.7492	F(2,26)=2.3469

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

Table B11: Modelling the Change in the Pool of Inactive Teachers for Males (DPITM) using Ordinary Least Squares Estimation

Independent variable	***(1)***	***(2)***
Constant	16707.0*** (4.85)	16860.0*** (6.19)
Trend	-54.1754** (-2.31)	-72.4607*** (-2.81)
Change in the pool of inactive male teachers lagged one period (DPITM_1)	0.5061*** (4.99)	0.4069*** (4.70)
Male graduate unemployment (UGM)	-74.5337 (-1.47)	-185.460*** (-3.94)
Male relative wages (RWM)	-11356.1*** (-4.00)	-10453.7*** (-4.53)
Real GDP growth (GDP95)	-34.9427 (-0.524)	-85.2435 (-1.58)
Trade union density (TUD)		-1212.99** (-1.89)
Proportion of male school leavers with 2 or more A-level passes lagged two periods (Q2AM_2)		19394.6*** (4.66)
No of obs.	40	40
R-square	0.80	0.88
AR(2) test	F(2,32) = 0.71846	F(2,30) = 0.09928

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

Table B12: Modelling the Change in the Pool of Inactive Teachers for Females (DPITF) using Ordinary Least Squares Estimation

Independent variable	***(1)***	***(2)***
Constant	44798.4*** (3.47)	38818.3** (2.72)
Trend	-548.431*** (-3.58)	-441.307** (-2.35)
Change in the Pool of Inactive Teachers for females lagged one period (DPITF_1)	0.6540*** (4.78)	0.6584*** (4.81)
Female graduate unemployment (UGF)	-109.244 (-0.655)	-72.8297 (-0.426)
Female relative wages (RWF)	-16808.6*** (-3.01)	-16958.5*** (-3.04)
Real GDP growth (GDP95)	-4.47296 (-0.0303)	25.7805 (0.171)
Fertility rate lagged one period (FER_1)		65.7011 (0.988)
Trade union density (TUD)		519.562 (0.197)
Proportion of female school leavers with 2 or more A-level passes lagged two periods (Q2AF_2)		15292.8 (1.37)
No of obs.	38	38
R-square	0.94	0.94
AR(2) test	F(2,28) = 2.1470	F(2,27)= 2.0157

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

In this section, we detail the attempt to apply a dynamic model to examine the relationship between the economic cycle and teacher supply in the UK. We have measured teacher supply using three variables, namely, the teacher-pupil ratio, attrition rates and the change in the pool of inactive teachers and have used these variables by gender. As a measure of the condition of economy, we have used real GDP growth and graduate unemployment as right hand side or independent variables.

Summarising the results, our autoregression distributed lag model using the OLS estimation method show a non-existence relationship between the economic cycle and teacher supply (measured by the teacher-pupil ratio variable. Real GDP growth and graduate unemployment appear insignificant in all our estimations and the magnitude of impact was so small that it was difficult to draw any prospective link between teacher-pupil ratios and the two variables.

For females, fertility is found to be a significant factor affecting female teacher-pupil ratios. As fertility increases, as expected, has an adverse effect on the female teacher-pupil ratio.

Extending our analysis to examine the male and female attrition rates, the results are also rather dismal with only the male attrition rate regressions showing some significant relationship between our measures of the economy's condition and teacher supply. Male attrition rate appear to have a significant relationship with male graduate unemployment, male relative wages, real GDP growth and teacher quality, proxied by the proportion of school leavers with 2 A-level passes. The significant RWM in the male attrition rate results and not in the female attrition rate regression results also points towards some support for evidence from cross section data (refer to Dolton and Mavromaras, 1994) that males are much more likely to be influenced by wages than females. The significance of the male graduate unemployment and real GDP growth variables with male attrition rate are blurred by the low magnitude obtained on the coefficient of our two variables of interest.

When we use DPIT according to the two genders, DPITM for the males and DPITF representing the females as a dependent variable in our regression, we obtain similar results where the male equations appeared to show more variables to be significant as compared to the female equations. In the male regressions, all variables were significant, especially when we included the controls for trade union density and teacher quality. The changes in male PIT were affected negatively by real GDP growth (GDP95), male graduate unemployment (UGM), relative wages (RWM) and trade union activities (TUD). Teacher quality (Q2AM_2) has a positive and significant relationship with DPITM, which again raises the issue of the higher likelihood of teachers with better examination scores leaving the teaching profession.

From the female PIT regressions, we are only able to find a significant relationship between DPITF and RWF. This shows that wages matter to females when it comes to making the decision to leave teaching in the longer term. Fertility is not a significant influence on DPITF while in the female teacher-pupil ratio results; fertility has an adverse and significant effect on TPRF. This finding could indicate that there might be a difference between factors, which affects the females' decision to leave the teaching profession in the short run (possibly to fulfil household responsibilities) or in the long run. All the results that were obtained remained similar even when we replace our measure of the economic cycle (real GDP

growth) with the calculated dummy variable indicating expansionary and contractionary periods in the UK economy.

Appendix C: Econometric Modelling – USA Results.

In this section, we detail the findings of the analysis using the USA data. Following the integration inspection of the UK data, we subject the USA data to the same unit root tests. It should be noted that the time series that we have on the USA is of a shorter time span compared to the UK data set. Caution would need to be exercised when examining the unit root test results for the USA data. As raised earlier on, the unit root tests are based on asymptotic considerations and by only having a data set ranging from around 1970 to 2000 in the USA data set for estimation, we are faced with a considerably small sample size for a time series analysis. Data for the USA were not available by gender, therefore, only allowing us to carry out this part of the paper at the overall level.

The data that we utilise for the USA in the econometric modelling are detailed in the graphs below. Figure 29 shows the trend of the teacher-pupil ratio, TPRTOT in the USA from 1965 to 2000 while Figure 30 displays the other variables, which we will use in our econometric modelling.

Figure C1: Teacher-Pupil Ratio in the USA, TPRTOT, 1965-2000

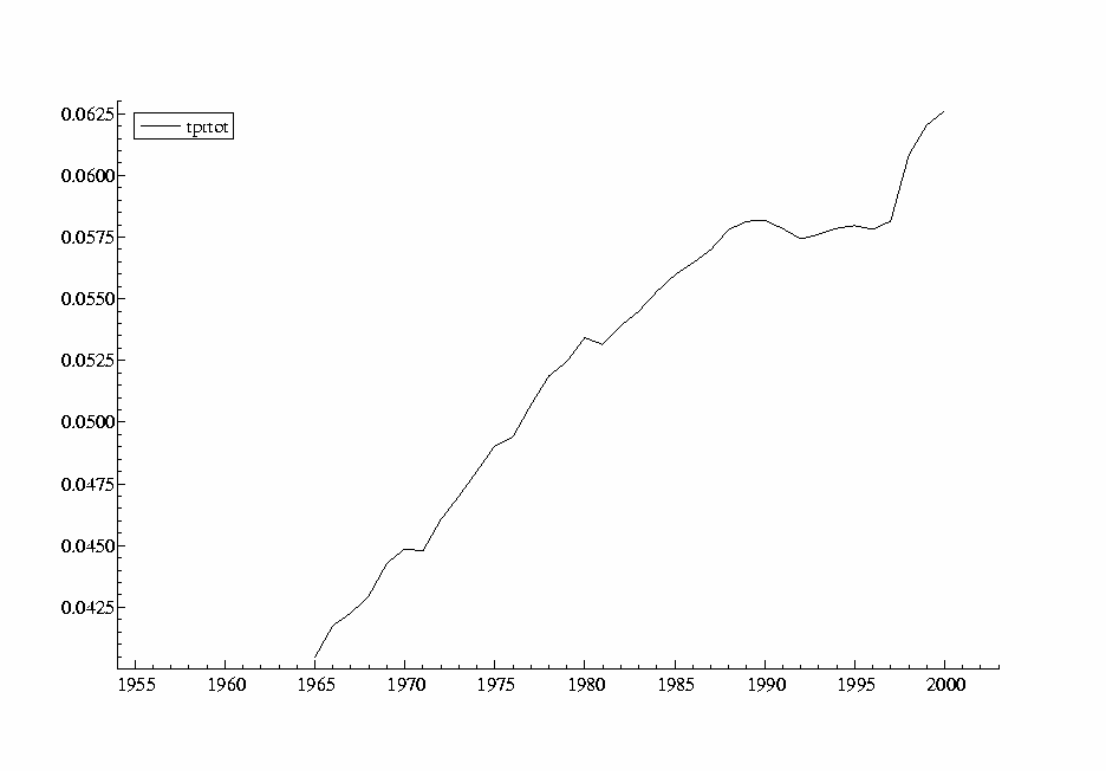


Figure C2: Relative Wages in the USA, 1960-2000

Figure C3: Graduate Unemployment in the USA, 1970-2000

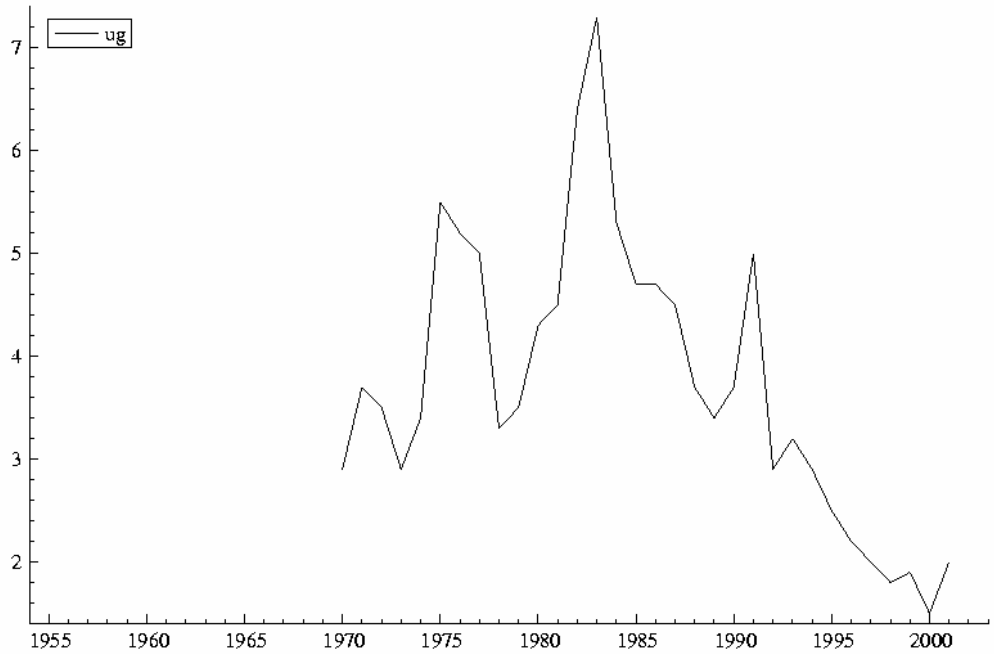


Figure C4: Real GDP Growth in the USA, 1960-2000

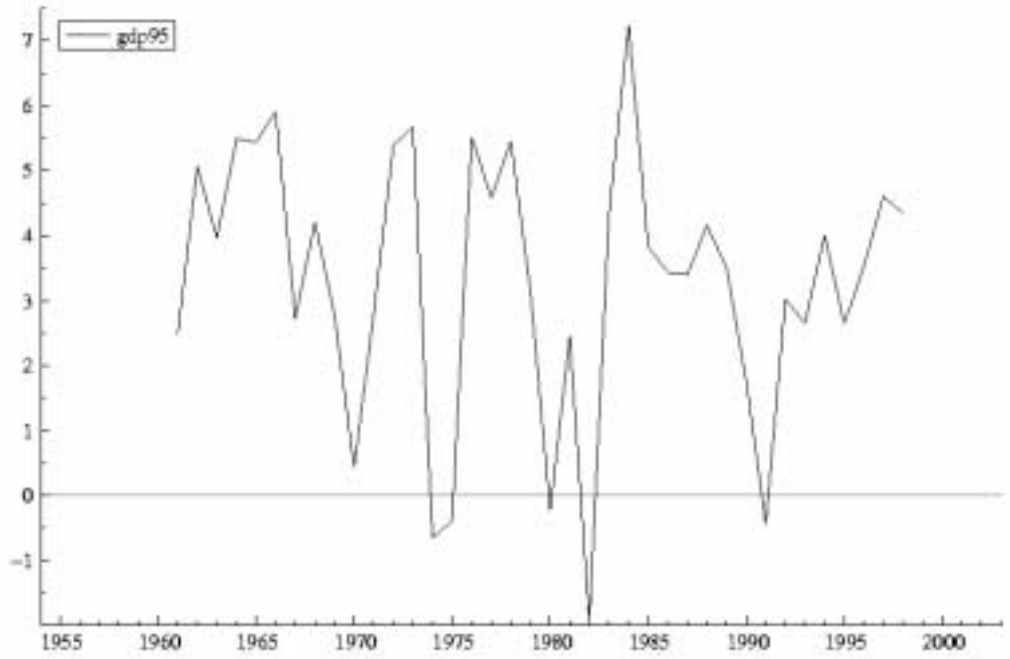


Figure C5: Government Expenditure on Education in the USA, 1955-2000

Graphically, the variables above seem to indicate stationarity properties (especially that of real GDP growth (GDP95_USA) and graduate unemployment (UG_USA)). Although the

earlier parts of relative wages (RW_USA) appear to show a tendency towards randomness, the later sections of this series appear to show a rather systematic movement in its series. To identify the integration properties of these variables, we apply the ADF test on each of these variables. The variables tested are total teacher-pupil ratio (TRPTOT), graduate unemployment (UG_USA), real GDP growth (GDP95_USA), relative wages (RW_USA) and the USA Government expenditure on education (GSE_USA).

Table C1 shows the results of the ADF regression for teacher-pupil ratio in the USA data set. The ADF regression with one additional lag produces residuals with no evident autocorrelation. Although the constant is significant at the 10 % level, the trend variable is insignificant.

Table C1: Unit Root test results, Teacher-Pupil ratio in the USA (TPRTOT)

Variable	***Coefficient***	***T-statistics [prob-values]***
Constant	0.0049	1.961[0.059]*
Trend	0.0006	1.491 [0.146]
Teacher-Pupil ratio lagged one period (TPRTOT_1)	-0.1177	-1.714 [0.097]*
Change in the Teacher-Pupil ratio lagged one period (DTPRTOT_1)	0.2753	1.634[0.113]
No of obs: 34 R-square = 0.17 F(3, 30) = 2.0045 [0.135] AR(2) test: F(2,28) = 0.086064 [0.9178]		

* Significant at the 10 % level

If we take the trend to be important in the fitted regression, the t-statistic on the lagged TPRTOT can be examined using the standard normal distribution. The prob-value for a one-sided test of the hypothesis that the true coefficient is zero is 0.049. Looking at these results, we feel that TPRTOT should be treated as stationary.

Table C2: Unit Root test results, Graduate Unemployment in the USA (UG_USA)

Variable	*Coefficient*	*T-statistics [prob-values]*
Constant	2.6311	2.30 [0.030]**
Trend	-0.0419	-1.85 [0.076]*
Graduate unemployment lagged one period (UG_USA_1)	-0.3498	-2.27 [0.032]**
Change in the graduate unemployment lagged one period (DUG_USA_1)	0.1007	0.521 [0.607]
No of obs: 29 R-square= 0.195 F(3,25) = 2.017 [0.137] AR(1) test: F(2,23) = 0.60702 [0.5535]		

* Significant at the 10 % level
** Significant at the 5 % level

From the ADF regression results for graduate unemployment in the USA, as displayed in Table C2, we find that both the drift and trend are significant at the 5 and 10 significance level respectively. It is apparent from the table of results that the interpretation of the t-statistic on the lagged graduate unemployment variable (UG_USA_1) can be interpreted using the standard normal distribution. It is fairly clear that we can treat UG_USA as a stationary variable based on the above results.

As predicted from the real GDP growth data plot, the real GDP growth variable in our USA data set is stationary. The results of the ADF regression on GDP95_USA (Table 16) confirm the integration property of this variable, i.e. that it is stationary. The trend variable is not significant in the ADF regression and based on this, we use the DF tables to infer if the USA's real GDP growth variable is stationary or not. In the DF tables, the critical value is –3.5386. The t-statistics, which we obtained on our GDP95_USA variable, is –4.7094, subsequently allowing us to reject the null hypothesis that GDP95_USA is integrated order 1 (non-stationary).

Table C3: Unit Root test results, Real GDP Growth in the USA (GDP95_USA)

Variable	*Coefficient*	*T-statistics [prob-values]*
Constant	4.0039	3.03 [0.005]***
Trend	-0.0248	-0.730 [0.470]
Real GDP growth lagged one period (GDP95_USA_1)	-1.0198	-4.71[0.000]***
Change in real GDP growth lagged one period (DGDP95_USA_1)	0.2860	1.68 [0.102]
No of obs: 36 R-square= 0. 442 F(3,32) = 8.461 [0.000]*** AR(2) test: F(2,30) = 1.0568 [0.3601]		

* Significant at the 10 % level
** Significant at the 5 % level
*** Significant at the 1 % level

Table C4: Unit Root test results, Teacher Relative wages in the USA (RW_USA)

Variable	*Coefficient*	*T-statistics [prob-values]*
Constant	0.1514	1.90 [0.066]*
Relative wages lagged one period (RW_USA_1)	-0.1334	-1.91[0.065]*
Change in relative wages lagged one period (DRW_USA_1)	0.1169	0.774 [0.444]
Change in relative wages lagged two periods (DRW_USA_2)	0.3712	2.41 [0.021]**
No of obs: 38 R-square= 0.197 F(3,34) = 2.786 [0.056]* AR(2) test: F(2,32) = 0.58474 [0.5631]		

* Significant at the 10 % level
** Significant at the 5 % level

The relative wages time series data is also stationary based on the ADF regression result that we presented in Table C4. The drift or constant in the regression is significant and we believe that this coefficient is a non-zero, which allows the usage of the standard normal distribution of the t-statistics in examining the integration properties of this variable. Based on a one-sided test on the prob-value obtained (0.037) on the lagged relative wages variable, we find that RW in the USA data set is stationary.

Table C5: Unit Root test results, Government expenditure on Education in the USA (GSE_USA)

Variable	*Coefficient*	*T-statistics [prob-values]*
Constant	0.4516	2.66 [0.011]**
Government expenditure on Education lagged one period (GSE_USA_1)	-0.0895	-2.46 [0.018]*
Change in Government expenditure on Education lagged one period (DGSE_USA_1)	0.1626	1.11 [0.275]
No of obs: 42 R-square= 0.181 F(2,39) = 4.323 [0.020]** AR(2) test: F(2,37) = 0.97238 [0.3876]		

* Significant at the 10 % level
** Significant at the 5 % level

Table C5 reports the ADF regression results for GSE_USA, the USA Government expenditure on education. The drift or constant is significant at the 5 % significance level. Looking at the t-statistics for the lagged GSE variable, it would be reasonable to treat GSE_USA as stationary.

Looking at the results of the unit root testing using the ADF regression, we find that we can treat all the USA variables as stationary and therefore, allow us to run the regression for the USA without having to consider the cointegration methodology. The USA teacher supply and economic cycle dynamic model can be written as the following equation, while the results of this regression is tabulated in Table C6: -

$$TPRTOT = \alpha + \beta_1 TPRTOT_{t-1} + \beta_2 GDP95\_USA + \beta_3 RW\_USA + \beta_4 UG\_USA + \beta_5 GSE\_USA + \varepsilon_t$$

Column (1) of Table C6 shows the regression using only the main variables of investigation, i.e. overall teacher-pupil ratio lagged one period, real GDP growth, relative wages and graduate unemployment. Column (2) has the added Government expenditure on education.

Table C6: Modelling Total Teacher-Pupil ratio in the USA (TPRTOT) using Ordinary Least Squares Estimation

Independent variable	***(1)***	***(2)***
Constant	0.0143*** (3.16)	0.0146** (2.03)
Trend	0.0001 (1.46)	0.0001 (1.13)
Total Teacher-Pupil ratio lagged one period (TPRTOT_1)	0.8503*** (8.98)	0.8448*** (6.04)
Real GDP growth in the USA (GDP95_USA) divided by 100,000	4.0658 (0.833)	3.9789 (0.760)
Relative wages (RW_USA)	-0.0071** (-2.68)	-0.0070** (-2.04)
Graduate unemployment (UG_USA) divided by 100,000	-3.7185 (-0.313)	-3.5302 (-0.280)
Government Expenditure on Education (GSE_USA)		-4.4701 (-0.054)
No of obs.	29	29
R-square	0.99	0.99
AR(2) test	F(2,21) = 0.0114	F(2,20) = 0.0141

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

Data Appendix

In the UK Dataset.

Aggregate Unemployment (UA)

Aggregate unemployment is the UK defined unemployment rate, which is based on the number of claimants unemployed as a percentage of the estimated total workforce. Data was collated from the Annual Abstract of Statistics.

Attritions (W)

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

Dummy variables

dumNC – This is a dummy variable representing the years where the National Curriculum was enforced in the education system (DfES, 2002). The National Curriculum was introduced in 1988 and implemented in the following year. Hence, we use the 1 dummy in the years 1989-2000.

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.

Education Expenditure as a percentage of GDP (GSE)

GDP data was taken from the ONS website (quoted under our explanation on Gross Domestic Product) while the education expenditure data was taken from the Annual Abstract of Statistics.

Excess demand for teachers (EX)

Excess demand for teachers is calculated by taking total modified demand for teachers minus the supply of teachers as described above. We have this measure for the primary teachers *(EXPRI)*. However, in the secondary teacher sub-group *(EXSEC)*, it was not possible to calculate the modified demand. In order to do this, a breakdown of secondary level teaching

was required (i.e. we would have had to be able to identify the number of teachers teaching pre and post 16 levels).

Expenditure per student in Higher Education (HE) by the Government (EPS)

Higher Education (HE) expenditure data was extracted from the various editions of the Statistics of Education: Volume 5 on Finance and Awards. HE expenditures include expenditure on Universities, Further Education and Teacher Training. The data for 1994 onwards were extracted from the DfES publication: Education and Training expenditure since 1988/89, 1989/90, 1990/91 and 1991/92. The data that we use are in real terms (according to January 1987 prices).

Fertility of women (FER)

Fertility rates for women were extracted from the Annual Abstract of Statistics. The rates used are rates per 1000 women aged 15-44.

Graduate Unemployment (UG)

The graduate unemployment data series is calculated using data 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 5 years, the publication of university statistics was taken over by the Higher Education Statistics Agency (HESA). The graduate unemployment measure follows the definition used in Johnes, et al. (1987) as below:

$$ug = \frac{UNEMP + TEMPJOB}{GRADS-UNAVAIL-UNKNOWNS}$$

Where

ug = graduate unemployment

UNEMP = graduates believed to be unemployed
TEMPJOB = graduates in short-term jobs
UNAVAIL = graduates not available for employment
GRADS = total graduates
UNKNOWNS = graduates for whom no information is available.

Male and female graduate unemployment is measured using the same data sources and definition.

Gross Domestic Product (GDP)

This measures the UK's GDP growth and was taken from the ONS website at http://www.statistics.gov.uk/statbase/tsdataset.asp?vlnk=205

New Entrants to Teaching (E)

New Entrants to teaching refers to those without any teaching experience in the maintained, assisted or grant-aided sector. This series of data was taken from the DES/DfES Statistics of Education: Teachers in England and Wales. This series of data was collected for the males and females from the same source of publication.

Participation Rate in Higher Education (PAR)

The participation rate in Higher Education (HE) measures the proportion of UK's 15-19 year old population (*Source: Annual Abstract of Statistics*) in Higher Education. Higher Education here refers to all university, further education and Initial Teacher Training first year students. Further education students are all those in the advance courses offered by colleges and further education institutions. The definition of higher education students follows that used in the Robbins Report (1963) on Higher Education in the UK. In the compilation of further education students, a caveat that applies is for data from 1981 onwards. In these figures, the overseas students were included and hence were removed to ensure that the series was consistent. Therefore, for the years where the overseas student component was included, we have assumed that 30 % of the males in further education were from abroad and for the females, 23 % of them were from abroad. The data was extracted from Volume 6 of the Statistics of Education on Universities (DES publication) for university student figures and later HESA's publication on Higher Education Students from 1994 onwards. For the further education and Initial Teacher Training figures, we obtained these from Volumes 3 and 4 respectively in the DES/DfES Statistics of Education.

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.

Pool of Recoverable Teachers (PRT)
The Pool of Recoverable Teachers (PRT) contains the teachers who have left teaching, and they are also teachers who can be enticed back into the teaching profession.

In estimating this variable, the male PRT is considered as a flow, whereby each year is treated separately, once the men leave in the previous year, they are likely not to return. On the other hand, the females in the PRT will be a stock whereby those who would have left the profession in the previous year(s) can be enticed back into the profession at some point of time.

In calculating the PRT among the male teachers, we have applied this logic and assumption: - If the number of male success in Initial Teacher Training is greater than the number of male entrants into teaching, we use the attritions of men under 60 plus the number of male entrants into teaching as the PRT change for that year, otherwise, we assume PRT change for men to be zero. This means that if there are more men qualifying to teach than those who entered teaching, we are assuming that the number of men who can be enticed back into the profession are equal those who leave plus those who entered into teaching in that particular year.

In the case of the females, the stock calculation of the female PRT includes the PRT stock of women in the previous year + those aged 25 to 34 who will not return into teaching once they leave (we have assumed that 55 % of women in this age group who leave and are thought unlikely to return) – those who are retiring among the PRT stock – those who enters Teaching either immediately or at some point after the completion of their Initial Teacher training course (as noted in the PIT calculation, this is 80 % of those completing their Initial Teacher Training. The 55 % of women who are unlikely to return is calculated based on the proportion of female re-entrants out of the average number of female attritions (below the age of 60) in our data set. Total PRT is the PRT of males plus the PRT of females.

Proportion of Graduates with First Class Degrees or 2:1 Degrees (QD1 and QD21)

This variable denotes the percentage of those completing a degree with First Class Honours out of the total number of first-degree completers at the end of the academic year. Likewise, the proportion of graduates with 2:1 degrees consist of those completing a degree at the Second Upper honours division out of the total number of first-degree holders. Data is taken from the various publications on Higher Education Statistics in the United Kingdom, i.e. the DES Statistics of Education: Volume 6 on Universities, Higher Education Statistics published by the University Central Council on Admissions and HESA's first Destination of University Graduates.

Proportion of School Leavers who become graduates 3 years later (SLG)

This variable is one of the few variables which is used as a measure of potential teacher quality in this paper. The formula used to calculate this measure of quality proxy is as follows:-

$$slg = \frac{\text{number of first degree holders}_{(t)}}{\text{number of school leavers}_{(t-3)}}$$

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.

Proportion of Teachers with Degrees (QTG)

The proportion of teachers with degrees data series is taken from the annual DES/DfES publication on Teachers (i.e. Statistics of Education: Teachers in England and Wales).

Recruitment from Returnees to Teaching (R)

These are the re-entrants into teaching and the data is obtained from DES/DfES Statistics of Education: Teachers in England and Wales publication. The re-entrants are teachers with pervious service in any maintained, assisted or grant-aided sector but how was not in such service in that sector at the beginning of the year. The returnees by gender are also collected from the same publication.

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.

Student grant in Higher Education (GHE)

The student grant refers to grants for maintenance (hence, excluding the tuition fee element) given to first degree and comparable to first-degree students in Universities or Further Education Establishments. This includes both the assessed contributions (by parents/spouses/students) and the LEA element. This is the rate for each academic year and was extracted from Table 6 or 7 of the DES/DfES Statistics of Education: Volume 5 on Finance and Awards. For the years 1961-1974, the grant was calculated by adding the total amount of maintenance by parents/students and the LEA, and then divided by the number of students. This was done because the figures for the data were not presented in the same format as in the later years. For the years 1988, 1998 and 1999, only the LEA element was published. To obtain the parents element and the total rate of grant, averages of previous years were taken and an estimate of the assessed contribution from parents/spouses/students and total rate was calculated.

Supply of Teachers (S)

This variable refers to the number of teachers in service as of 31st of March. Figures were extracted from the Statistics of Education: Teachers in England and Wales as published by the Department for Education and Skills. Our data also contains teachers in service by gender, which we have labelled, *SM* (male teachers in service) and *SF* (female teachers in service).

Teacher Inner London Allowances (AIL)

The Inner London allowances for teachers for the years 1945-1983 were taken from the Scale of Salaries for teachers in primary and secondary schools: England and Wales. Data for 1984-1987 were based on the report of the interim advisory committee on School Teachers' Pay and Condition, 31st March 1988. Data for the rest of the years, i.e. 1988-2000 were taken from the School Teachers' Pay and Conditions document. The division into the inner, outer and fringe area allowances only began in 1974. Prior to this year, it was only one rate for all teachers in London, regardless of the area.

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:

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

The Demand for Teachers (D)

The annual demand for teachers for the years 1946-1990 was taken from Bee and Dolton (1995). In this paper, D was calculated by using the pupil-teacher ratio (PTR) targets to the actual pupil numbers. We continued the usage of the PTR in 1990 for the years 1991-2000, as there was no readily identified PTR set by the Government after 1990. While this variable will give us a measure of the teachers needed according to targeted PTR set by the Government, we have another measure where demand is modified according to the PTR that actually prevails. This variable is the total modified demand for teachers. In calculating the modified demand, the actual PTR replaces the targeted PTR when it is lower than the latter.

<u>In the USA Dataset</u>

Additional Demand (EX, EXELE and EXSEX)

In estimating the additional demand for teachers in the USA, we applied Weaver's (1980) demand and supply of teachers' model, which calculates the additional teachers needed due to changes in pupil enrolment, teacher turnover rate and change in the pupil teacher ratio (PTR). The additional teachers sought are also measured by the level of schooling, i.e. Elementary *(EXELE)* and Secondary *(EXSEC)*.

Aggregate Unemployment (UA_USA)

The aggregate unemployment data was taken from published series made available on the Internet by the Bureau of Labor Statistics (http://www.bls.gov/cps/cpsaat1.pdf). This measure of unemployment covers those aged 16 and above as a percentage of the labour force.

Education Expenditure as a percentage of GDP (GSE_USA)

Education Expenditure and Gross Domestic Product data were taken from the NCES, Digest of Education Statistics.

Fertility of women (FER_USA)

Fertility rates for women in the USA were extracted from the National Vital Statistics report. This report can be assessed through the Internet at http://www.cdc.gov/nchs/fastats/births.htm and http://www.cdc.gov/nchs/fastats/pdf/nvsr50_05t1.pdf.

Graduate Unemployment (UG_USA)

The Bureau of Labor Statistics in the USA provided this series of data extracted from the Current Population Survey (CPS). The graduate unemployment rates refer to those aged 25 to 64 who are college graduates and are unemployed. A caveat to note is that from 1992 onward, the CPS has classified educational attainment by degree received. Prior to 1992, educational attainment was classified by years of school completed. In the latter case, we have taken the unemployment rate of those with 1 to 3 years of college education in line with the UK definition of graduate unemployment, which covers those with a first-degree qualification.

Gross Domestic Product (GDP_USA)

This measures the USA's GDP growth and is taken from the Bureau of Economic Analysis website at http://www.bea.doc.gov/bea/dn/gdpchg.xls. To obtain the real GDP growth, GDP figures were deflated using the USA's GDP deflator (1995=100) and the growth rates recalculated to reflect the values in real terms.

Recruitment from Returnees to Teaching (RF)

The proxy used for re-entrants into teaching in the USA is the additional demand for teachers filled in by re-entrants using re-entrant rates taken from Weaver's dataset and also from the

NCES's School and Staffing Survey (SASS) results. The SASS was conducted in 1987-88, 1988-89 and a follow up survey in 1994-95. However, the results reported were only for the overall level and therefore the re-entrant rates by schooling level could not be obtained. At the individual schooling level, we have maintained the rates as used by Weaver.

Relative Teacher/Non-teacher wage (RW_USA)

For the USA, school teachers' average pay was extracted from the various editions of the Digest of Education Statistics, which had also provided the average earnings of full-time salaried employees in the USA (representing the non-teacher sector). The data is deflated to reflect real wages using the USA's Consumer Price Index (CPI), 1982-84=100.

Supply of Teachers (S, SE and SS)

The number of teachers in service in the USA was extracted from the various editions of the Digest of Education Statistics published by the National Center for Education Statistics (NCES). The number of teachers is divided into those teaching in Elementary schools *(SE)* and those teaching in Secondary schools *(SS)*. The NCES defines the Elementary level to include the Kindergarten level up to the 8^{th} Grade while the Secondary level consist of 9^{th} Grade classes to the 12^{th} Grade classes.

<u>In the OECD and WEI Dataset</u>

Absolute GDP growth 1998-1999

This measures the absolute GDP (per capita, in equivalent US dollars converted using a purchasing power parity price index) growth in the OECD and WEI countries between 1998 and 1999. GDP data was taken from the World Bank database (http://www.worldbank.org/data/onlinedatabases.html).

Expenditure on educational institutions as a percentage of GDP

Data were taken from the OECD (2001b), and they refer to the direct and indirect expenditures on educational institutions, in primary and secondary education (1999) as a percentage of the Gross Domestic Product.

GDP growth 1998-1999 (%)

This measures the GDP (per capita, in equivalent US dollars converted using a purchasing power parity price index) growth in the OECD and WEI countries (%) between 1998 and 1999. GDP data was taken from the World Bank database (http://www.worldbank.org/data/onlinedatabases.html).

Growth in the size of the population at the age of primary/lower secondary and upper secondary education (%)

This is calculated as a proxy of the growth in demand for education, using the relative change in the population at the age of primary/lower secondary and upper secondary education between 1995 and 1999.

Lower secondary

This is a dummy variable that is equal to 1 if the observation refers to teachers of lower secondary education (primary education teachers is the reference group).

Student/teacher ratio

Ratio of student relative to their teachers for public and private institutions in primary, lower secondary and upper secondary education (1999).

Teachers and staff (%)

Teachers and staff in primary, lower secondary and upper secondary education as a percentage of the total labour force in 1999.

Teachers' salaries

This variable refers to the teachers' average salaries per statutory hour of teaching in primary education, lower secondary education and upper secondary education in 1999. The average salary is worked out using the OECD (2001b) data on starting salary, salary at top of the scale, years from starting to top salary and the percentage of teachers by age group.

Teaching hours per year

This refers to the statutory number of teaching hours per year (1999), i.e. net contact time in hours per year in primary, lower secondary and upper secondary education.

Upper secondary

This dummy variable is equal 1 if the observation refers to teachers of upper secondary education (primary education teachers is the reference group).

Women among teaching staff (%)

percentage of women among teaching staff in public and private institutions, in primary, lower secondary and upper secondary education.