Chapter 19

TEACHER SUPPLY

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Contents

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Abstract

This chapter presents an overview of economic models of teacher supply and explains the modeling implications for both cross-section and time series econometric modeling. Specifically the literature on the determinants of teacher recruitment, turnover, mobility and re-entry into the profession are reviewed. It reviews the empirical evidence from the US, the UK on the labor supply of teachers and assesses the variation in teacher's real pay across in aggregate across 35 countries in the world. It also provides suggests for fruitful areas of future research.

Keywords

teachers, labor supply, occupational choice

JEL classification: J44, J45, J31, J33, I2

1. Introduction

In most countries in the world there is frequently a shortage of qualified teachers. Teacher shortages are not a new phenomenon. In 1967, 83 out of 91 countries, when surveyed [see IBE/UNESCO (1967)] said they were experiencing a shortage of secondary teachers. Since then, a vast literature in education policy from many different countries, has described the teacher supply problems and suggested policies to handle their own version of the shortage. Why does the supply of teachers cause a problem? Simply stated, in most countries in the world, the market for teachers is dominated by the government (or the federal state authorities) in the sense that the demand for teachers is a public sector demand and often the government will set teachers wages. In this context the root of the problem will be that the relative wages in teaching are too low to attract young people into the profession.

It is difficult to overstate the importance of teacher supply issues. Accordingly the problems have received high profile attention in the UK and the USA. In a major high level review of the problems in the US education system Darling-Hammond (2000) suggests that qualified teachers are not only a major determinant of student achievement but also one of the most inequitably distributed resources. She documents how poor children are exposed to lower quality teachers and poorer curricula. She describes a range of policy options to successfully recruit, prepare, retain and support a diverse, well-qualified teaching force. She comes down in favor of policies which increase teacher salaries, provide teachers with more support, renewed efforts on training and recruitment including more proactive recruitment, improved mentoring and induction for beginning teachers and designing schools to provide more support for teaching and learning.

The approach of this overview will be to first provide some empirical insight into the market for teachers by examining the supply of teachers and their salaries in the UK, USA and the rest of the world. We then provide an overview of the different theoretical and statistical models which have been used in the literature to investigate the supply of teachers. Sections 4 and 5 of the chapter provide an overview of the results which have been found from various countries about the factors which empirically influence the supply of teachers.

2. Empirical evidence on teacher supply and salaries

2.1. Measuring teacher supply

The measurement of teacher supply and most specifically the changes in teacher supply from year to year is problematic. The teacher supply function would theoretically be described by knowing how many teachers would be prepared to work at any given teacher wage on offer. Such a supply function, based on aggregating individual potential supply decisions, is difficult to recover. To clarify the different concepts we employ the terminology used in the UK. In the data which exists in several countries there are a variety of ways in which the change in teacher supply can be measured:

1. Changes in the pool of inactive teachers (PIT), i.e., those who have previously qualified as teachers but are currently not working as teachers.
2. Changes in the size of the pool of recoverable teachers (PRT) – who are those members of the PIT who can, in fact, be induced to re-enter teaching.
3. Changes in the stock of those teachers actually in service. This is the Zabalza, Turnbull and Williams (1979) definition and it relies on the idea that this stock is the number of people actually employed at the current salary on offer.
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.

Figure 1 shows the teacher demand and supply elements that may be used to determine if the teacher labor market is in shortage or in surplus. Determining the demand for teachers is relatively more 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.

The supply of teachers as outlined in Figure 1 can be divided into two: the current supply of teachers and the potential supply. The current supply of teachers, consists of those who are currently in service in the teaching workforce. These teachers in service are denoted by "*s*" in Figure 1 and would contain those who are continuing teachers, 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 teaching. The number of students enrolled in the Initial Teacher Training (ITT) courses sustains the flow of new entrants as they can enter into teaching upon completion of their training. A shortage (*ex*) occurs when the demand for teachers is not matched by supply and a surplus occurs when the current supply of teachers exceeds the demand of teachers.

To complete the teacher supply and demand model, the outflow of teachers needs to be considered as well. Wastage makes up the outflow of teachers from the current supply. This group of leavers can be divided into those who leave at retirement age and those who leave for reasons other than retirement (i.e., those below the age of 60–65). When teachers (and those who are qualified to teach) leave the profession, they become inactive and enter the stock of potential teachers in the Pool of Inactive Teachers (PIT). In addition to the leavers below retirement age, the PIT also contains the ITT graduates who do not enter into teaching. A second component in the potential supply of teachers is the Pool of Recoverable Teachers (PRT). The teachers in the PRT are those who leave the profession but can be enticed to return to teaching and are therefore the main source of potential supply.

Using the distinctions in Figure 1 it is possible to argue that several of the variables which may exist in national data may serve as an adequate proxy for the state of teacher supply. It should be appreciated that there are limitations with all these proxy measures of the supply of teachers.

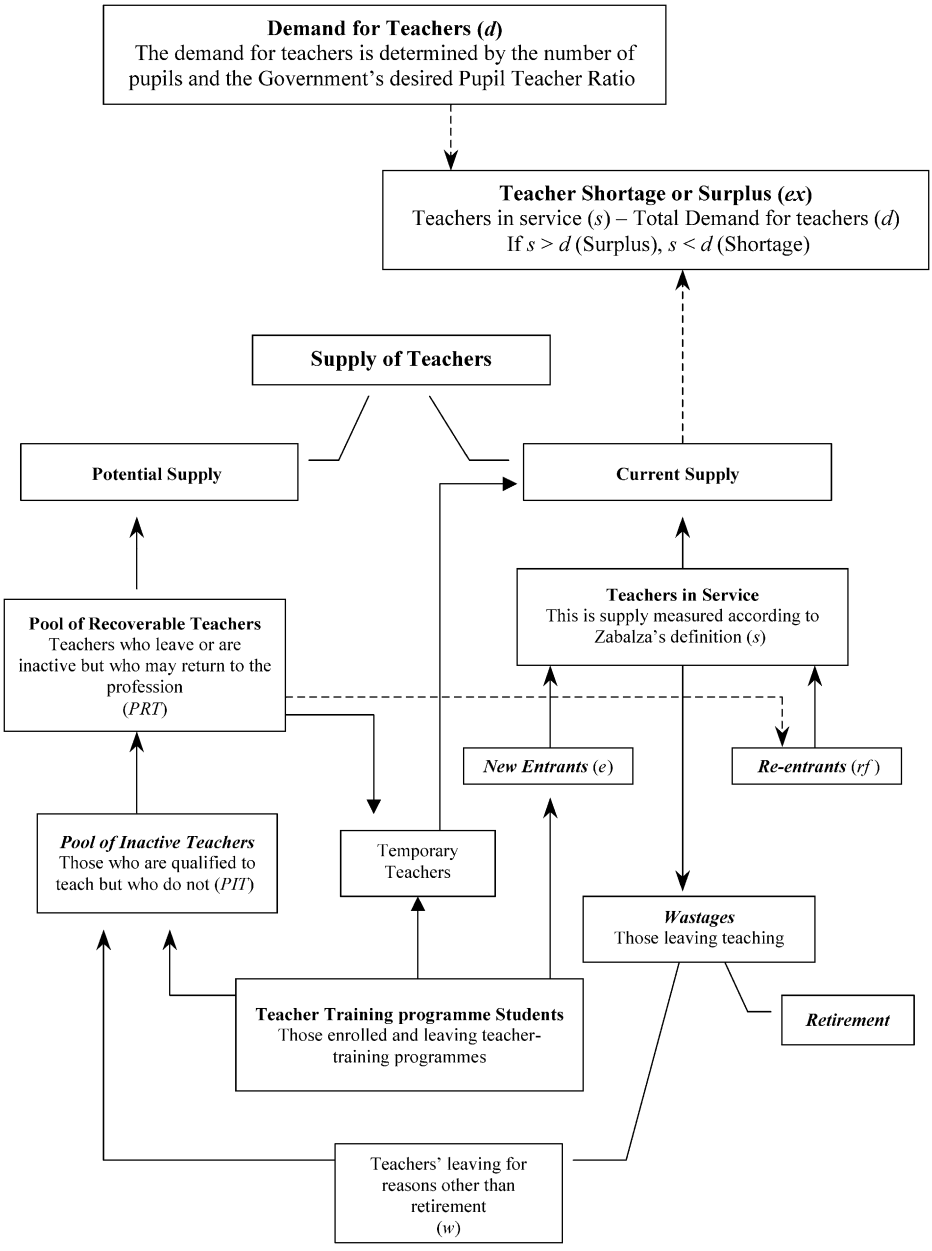


Figure 1. Teacher demand and supply.

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 true of the PRT. Using the Zabalza, Turnbull and Williams (1979) definition of supply – as the number of people actually in 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 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.

2.2. *Evidence from the US*

The empirical position on teacher supply and demand in the USA has been documented by Maaske (1951), Kershaw and McKean (1962), Kelsall and Kelsall (1969), Graybeal (1974), Corrigan (1974), Weaver (1983), Dimmock (1980), Haggstrom, Darling-Hammond and Grissmer (1988), Darling-Hammond (1989), Boe and Gilford (1992), Billingsley (1993), Boe, Bobbitt and Cook (1997), Grissmer and Kirby (1997), Flyer and Rosen (1997) and Darling-Hammond and Berry (1999). The account of the teacher supply position in the USA is brought up to date in Dolton, Tremayne and Chung (2003) and Dolton, McIntosh and Chevalier (2003).

In the USA, each Federal state is autonomous in acting as the teacher employer, deciding on the teacher training requirement, recruitment and pay issues. Therefore Dimmock (1980) suggests that the teacher labor market in the USA conforms to a *laissez faire* model. The USA does not have a set of consistently collected aggregate national education statistics. This means that although it is possible to obtain data on pupil enrollment changes and teacher numbers over time, other statistics such as the number of new entrants, new graduate teachers, re-entrants and wastage 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, that is, 1987–1988, 1990–1991 with follow-up surveys in 1988–1989, 1991–1992 and 1994–1995. In Figure 2 we graph the change in the pupil enrollment over the 1960–2000 period. From this graph it can be seen that the school pupil population was growing up until the 1970s then it declined until the 1980s before growing again from 1986. These trends will be reflected directly in the demand for teachers.

Figure 3 shows the number of teachers in the USA from 1960 to 2000. Teacher numbers in the USA were increasing throughout the 40-year period. Breaking it down into

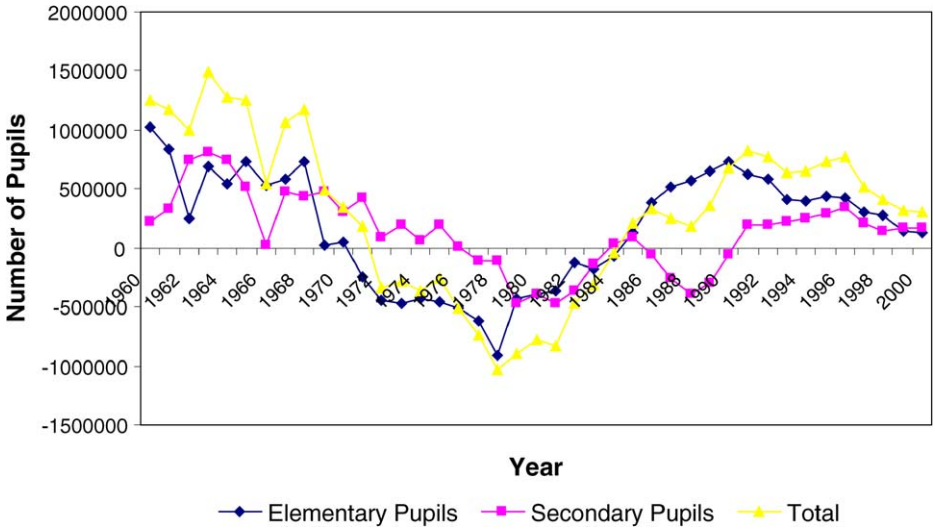


Figure 2. Pupil enrollment change in the USA, 1960–2000. *Source*: NCES.

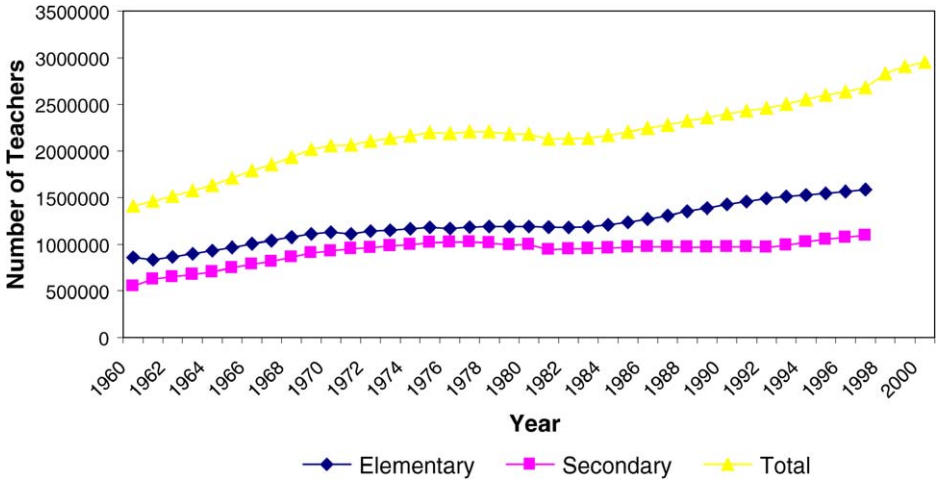


Figure 3. Number of teachers in the USA, by sector, 1960–2000. *Source*: NCES.

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 supply was encouraged by the post-war baby boom. 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%).

Putting the data on teacher and pupil numbers together it is possible to graph the teacher pupil ratio for the USA over the period 1965–2000. Figure 4 shows the trend of the teacher–pupil ratio in the USA from 1965 to 2000. In essence this is the pattern of teacher supply relative to pupil numbers. It suggests that on average pupils in the USA were taught in classes of 23 in 1965 – but this has fallen to classes of 16 by 2000. This represents a dramatic growth in teacher supply over the last 35 years in the USA.

In examining the teacher supply and demand situation in the USA, we can apply the model used by Weaver (1983) who looked at the number of additional teachers required in the event a change in 3 factors, i.e., the change in the teacher turnover rate, the change in the pupil–teacher ratio and the change in pupil enrollment. Additional demand was then derived from taking the total number of teachers required as a result of these 3 factors.

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. The supply of new graduates in Weaver's model is limited 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 1970–1980, he had to estimate the number of new graduates in teaching for his remaining years of 1980–1990.

Weaver used linear extrapolation to estimate the number of new graduates for the years 1980–1990. This extrapolation of the supply of new graduate teachers is based

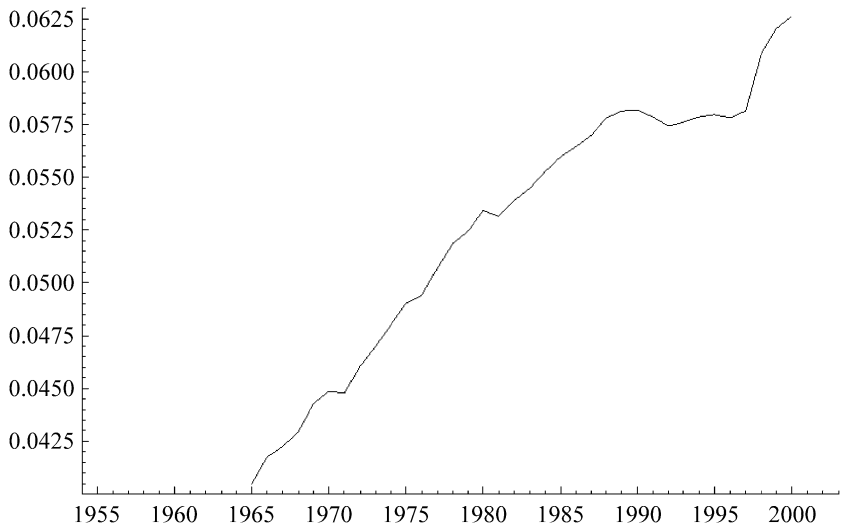


Figure 4. Teacher–pupil ratio in the USA, 1965–2000.

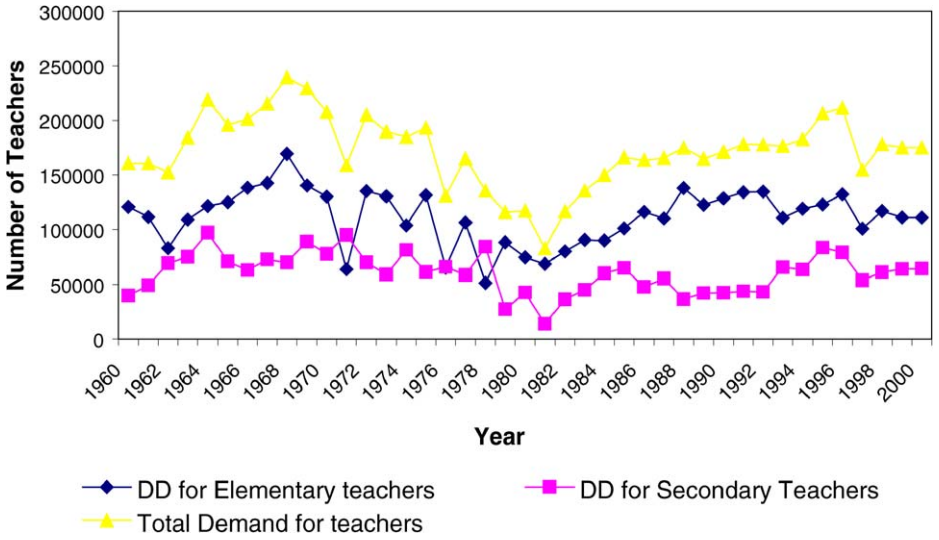


Figure 5. Additional demand for teachers in the USA, 1960–2000. *Source*: Weaver (1983) and own calculations.

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. Applying this same method it is possible to extend Weaver's data set to the year 2000. The total number of additional teachers required in the USA for the period 1960–2000 is shown in Figure 5.

One important factor which this research on teacher supply ignores is the quality dimension in the teacher stock. This is an important aspect of supply which has been variously treated by Ballou (1996), Ballou and Podgursky (1997, 1998a, 1998b), Lakdawalla (2001) and Corcoran, Evans and Schwab (2002). The suggestion has been that teacher quality has been falling in the US mainly due to the opening up of alternative career options for women. If this was correct then the "effective supply" as measured by the TPR in efficiency units may not be rising as graphed in Figure 4. This assertion has been questioned by Corcoran, Evans and Schwab (2002).

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 1994–1995", it is reported that the teacher attrition rate in public schools in the USA was 6.6 percent between the 1993–1994 and 1994–1995 school years. 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)].

In the 1994–1995 Teacher Follow-up Survey, the main reasons cited for leaving were retirement and pregnancy/child rearing. Many teachers in the USA were leaving the pro-

fession 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. There is also evidence that indicates that relative wages 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 labor market would need to be competitive enough to attract and retain teachers in the profession.

When the two elements of teacher supply and demand are interacted, the picture is that between 1945 and 1969, the USA faced a shortage of teachers but that there was a surplus of teachers in the decade after 1969 [Dimmock (1980)]. The main reason for this surplus of teachers in the 1970s was the falling number of pupils enrolled during this period. From Figure 2, the pupil number declined dramatically in the 1970s, especially among the elementary pupils. The decrease in the number of pupils enrolled caused the number of teachers required to decrease and hence, caused a teacher surplus.

In the past two decades there has been a shortage of teachers in the USA because of the increasing number of pupils. The shortage has been exacerbated by the fact that the teachers who were hired during the baby boom years are now approaching retirement. There has also been considerable political pressure at the federal level to reduce class size. Hence, there is now a need to fulfill additional demand for teacher as a results of the changing pupil teacher ratio and pupil enrollment, as well as 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.

Figure 6 graphs the trend in the relative teacher wages in the USA from 1959 to 2000. We can see that teachers earned 19% and 24% above the average wage in 1970 and 1990 respectively, but that in between these years teacher's relative pay has declined to between 6–8% of average earnings in 1959, 1979 and 1999. A major factor in the decline of teacher salaries in the 1970s was the surplus of teachers over these years. However, since teacher salaries are set at the state level it is more difficult to explain the process by which these salaries adjust to market forces.

In the next section of this chapter, we will examine why not only average relative wages in teaching are important for teacher supply but also the pattern of teacher and nonteacher pay over the life cycle is important. Figure 7 shows what the profile of female average teacher pay and nonteacher pay by college graduates is over the life cycle. We see from this figure that nonteacher pay is higher for most of the life cycle but that the two curves cross after about 30 years of work experience. The corresponding graph for men (not shown) does not have these two functions crossing. This finding is consistent with that described by Flyer and Rosen (1997). This suggests that the occupational choice of becoming a teacher or a nonteacher must be made not only on financial grounds. We return to this important question in the next section.

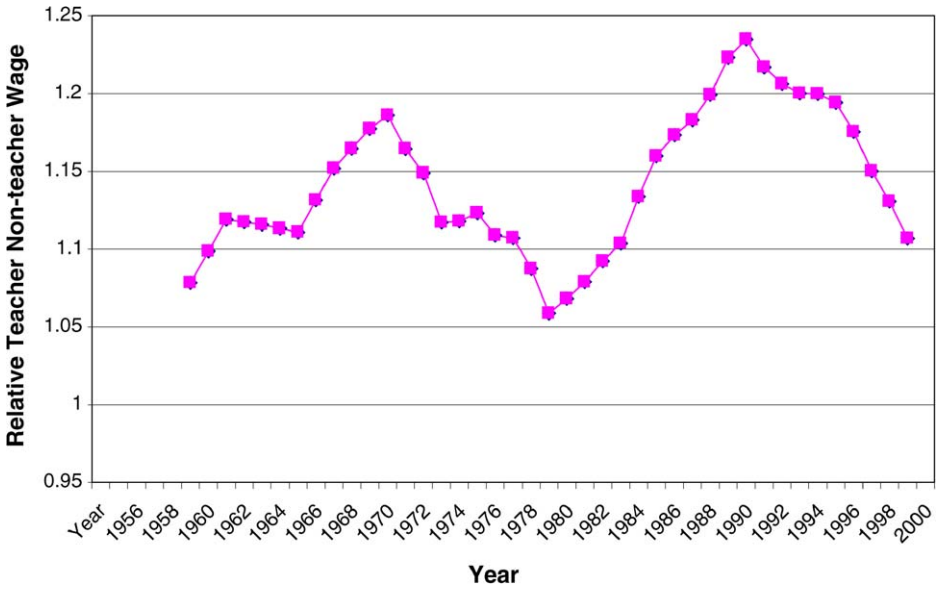


Figure 6. Teacher relative wages in the USA.

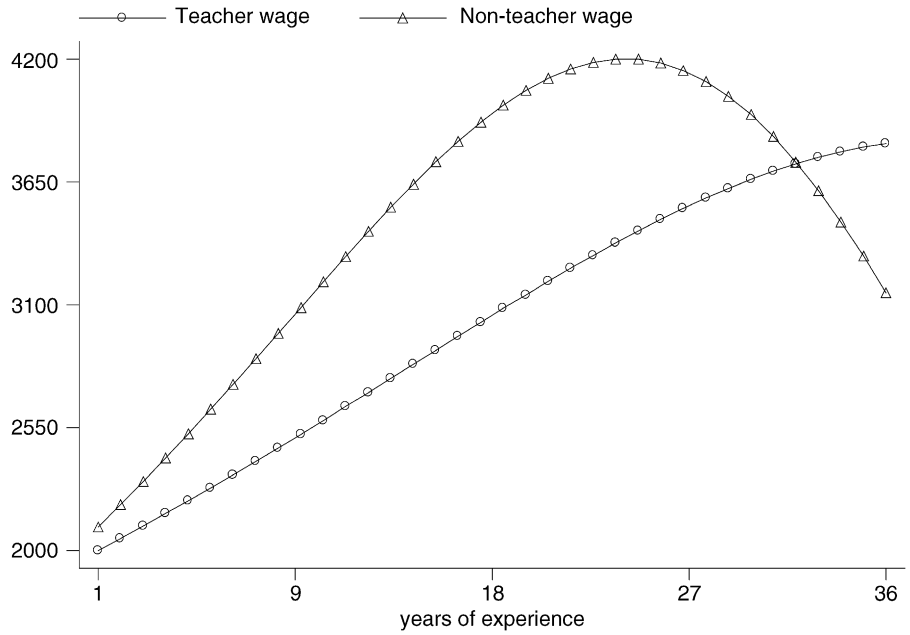


Figure 7. The life cycle average monthly female teacher and nonteacher wages of USA graduates ($2002).

2.3. Evidence from the UK

There has been a large literature summarizing the labor market situation for teachers in the UK over the last 30 years [Tropp (1957), Ahamad (1970, 1973), Zabalza, Turnbull and Williams (1979), Dimmock (1980), Blackstone and Crispin (1982), Booth (1989), Straker (1991a, 1991b), Grace (1991), Grace and Lawn (1991), Fidler, Fugl and Esp (1993), Wilson and Pearson (1993a, 1993b), Dolton (1996), Hutchings et al. (2000), Smithers and Robinson (2000a, 2000b, 2001)]. Edmonds, Sharp and Benefield (2002), Godwin (2002) and Ross and Hutchings (2003) all survey the alternative policies for attracting and retaining teachers in the UK. These papers provide a thorough overview of the institutional and administrative detail of the UK system of teacher pay and school organization. They include a description of the UK funding. They detail the various initiatives which have been used in the UK to attempt to overcome the problems with teacher shortage. This section reviews the empirical position regarding teacher supply and demand and the factors like relative teacher salaries which influence it.

Figure 8 graphs the trend in pupil numbers in the UK over the 1947–2000 period. The "switchback" nature of these trends show clearly the nature of the baby boom periods of the immediate post war period and that of the late 1960s. The graph shows how the balance of the demographic structure of the school population will shift the demand for teachers. In 1947 there were 3.7 million primary school pupils and only 1.2 secondary pupils. By 1984 there were 4 million of both primary and secondary pupils. This pattern will have a dramatic impact on the relative demand for primary and secondary school teachers.

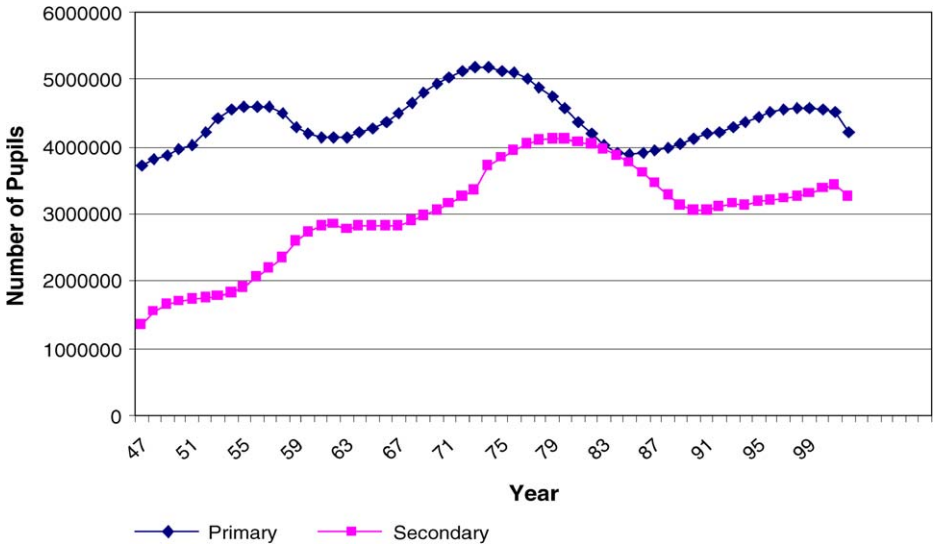


Figure 8. Primary and secondary school pupil numbers in the UK, 1947–2001.

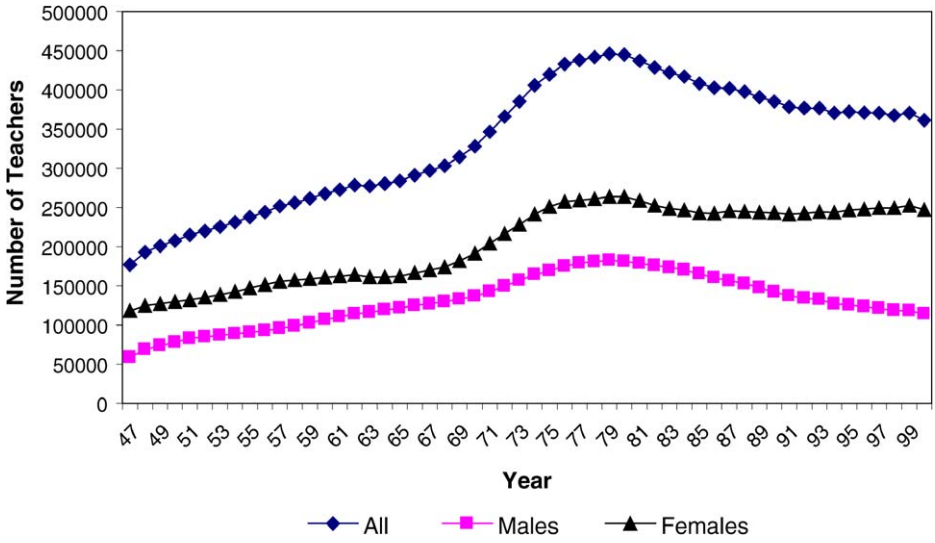


Figure 9. Teachers in service, UK 1947–2000. *Source*: Statistics of education.

Figure 9 depicts the situation of teachers in service in the UK for the period 1947–2000. The number of teachers in service rose markedly up until 1980 and has been declining since then. The number of teachers in service will be determined directly by the number of pupils to be taught and the pupil teacher ratios which are used. A similar pattern is observed among the male and female teachers. The ratio of female–male teachers in the UK for the period 1947–2000 is 60:40. Teaching is also a predominantly female occupation in most other OECD countries.

Looking at the information in Figures 8 and 9 we can derive the overall supply position by graphing the teacher pupil ratio experienced by pupils in the UK over the 1947–2000 period. This is graphed in Figure 10. It shows that the average child in a UK primary school was taught in a class of 29 in 1947; that this declined to 20 by 1990 and has subsequently risen to 23 in 2000. The average secondary school pupil was taught in a class of 27 in 1947, 16 in 1990 and 22 in 2000.

The interaction between supply and demand will tell us if there is a shortage or surplus of teachers in the UK. The number of pupils and the Government's published target pupil teacher ratio determines the demand for teachers. For example, in 2000, there were 4,278,123 primary school children (full-time equivalents). According to the Government's target pupil teacher ratio[1] there would be 21.2 primary school children for every primary school teacher, implying that over 210,000 primary school teachers are

[1] Successive government publications have included a figure for a desired target pupil teacher ratio for primary and secondary schools. See Bee and Dolton (1995) for the details of the UK government's published desired PTR.

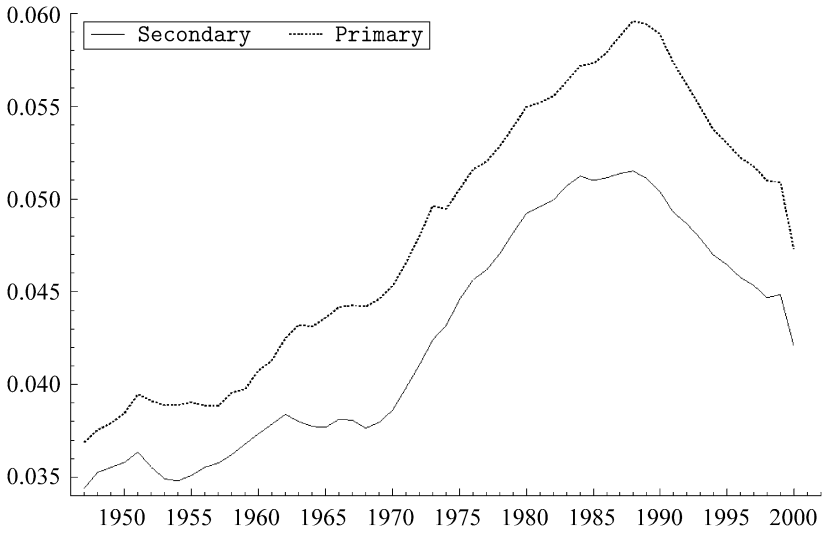


Figure 10. Teacher–pupil ratio in the UK, 1947–2000.

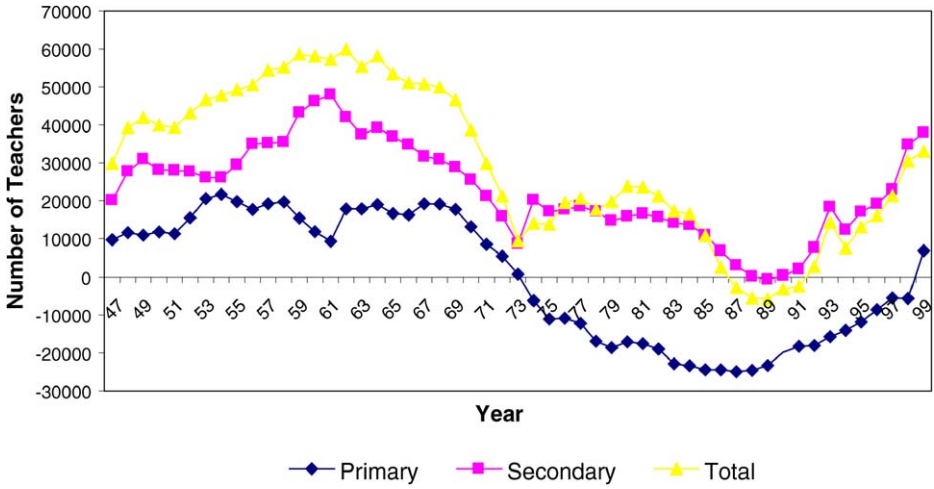


Figure 11. Excess demand of teachers, by sector, UK, 1947–2000. *Source*: Own calculations.

needed. In actual fact, there were over 183,000 primary school teachers in 2000, implying an excess demand of around 27,000 primary school teachers. A similar analysis for secondary school teachers reveals that there was an excess demand of nearly 16,000 teachers, giving the overall excess demand figure of approximately 34,000. Figure 11 uses this logic to chart the situation for all years since 1947.

The graph shows that there has been an overall excess demand for teachers almost continuously throughout this period. However, closer inspection shows that there has, in fact, been a surplus (negative excess demand) of primary school teachers over the 1973–1998 period. This is a feature of the market in the UK – namely that in some segments of the market there is a shortage and in others a surplus. Overall there is a shortage but this disguises the surplus of primary school teachers which is offset by the shortage of secondary school teachers and in particular science and maths teachers and teachers in London and the South East of England.

A major part of the structural determinants of teacher supply relates to the rate at which males and female teachers leave the profession during their careers, the extent of wastage from the profession and how it has changed over time and what has happened to the stock of inactive teachers and those who could return to the profession. We examine these factors for the UK in Figures 12–14. Figure 12 shows how women leave the occupation in much larger numbers during their child rearing and household production years than men but subsequently return to the job in their later life.

The average wastage rate by gender is graphed in Figure 13. It shows how on average around 10% of female teachers in the UK leave the job each year. Traditionally male wastage from teaching was much lower at around 5% up until the mid-1980s. Since then the rate of male wastage from the profession has risen markedly to around 8% per year in the 1990s. These trends give cause for concern for the UK government since male teachers are predominantly secondary school teachers and are more likely to be in science and maths subjects.

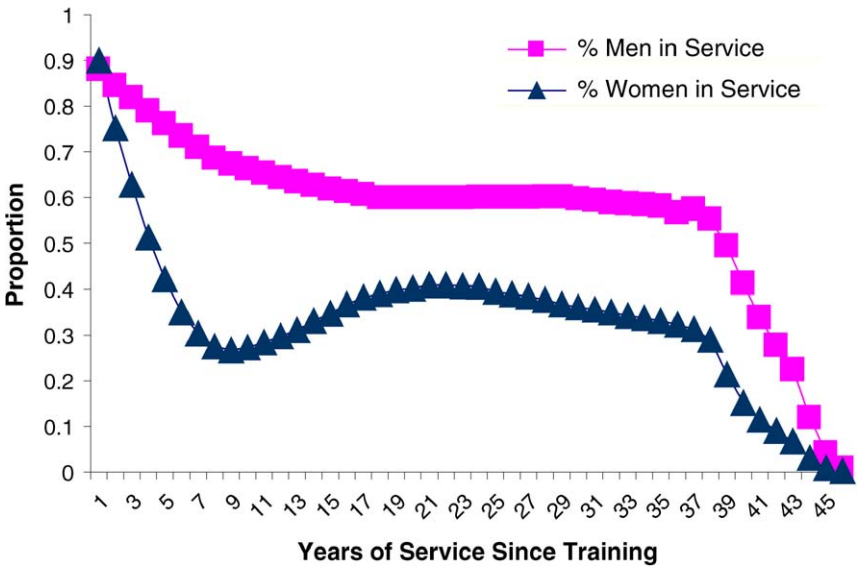


Figure 12. Exit rates of trained teachers by gender over experience.

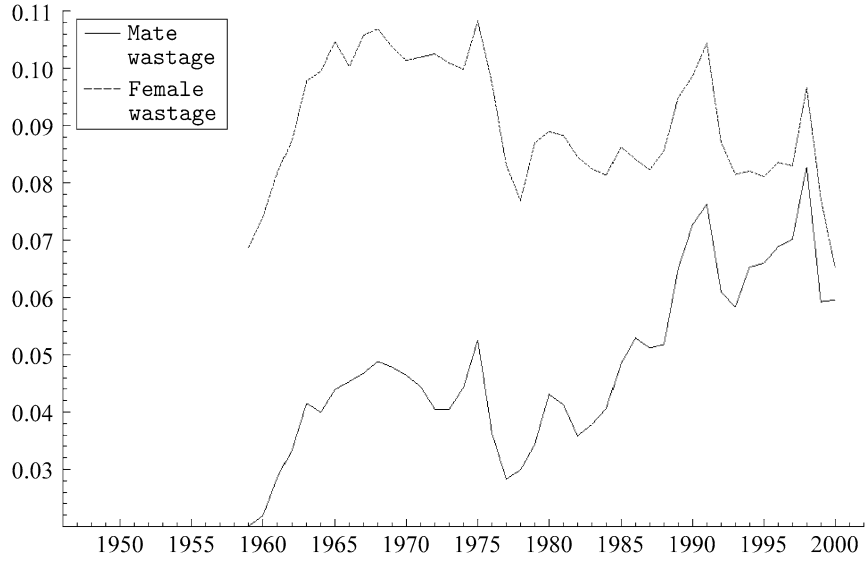


Figure 13. Male and female wastage rates in the UK, 1959–2000.

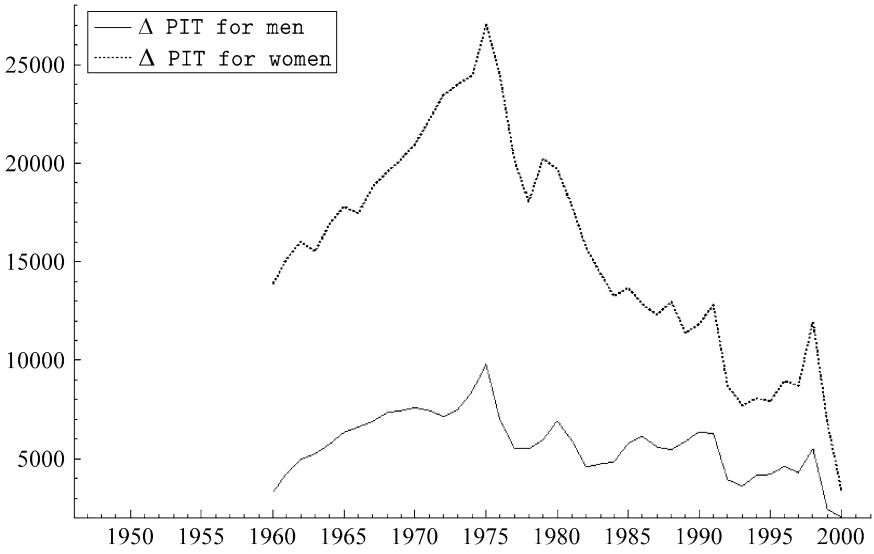


Figure 14. The change in the pool of inactive male and female teachers in the UK, 1960–2000.

The trend of the change in the male PIT and female PIT as presented in Figure 14 show an upward trend with a decreasing change over the years. This means that in every

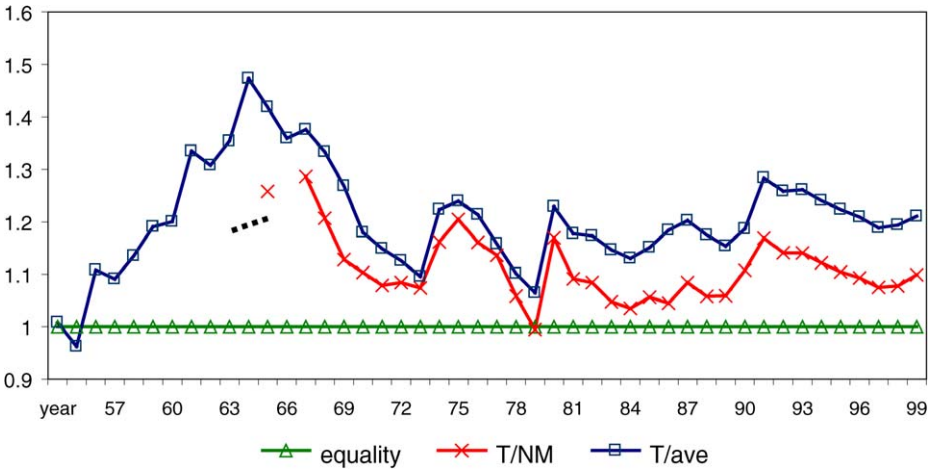
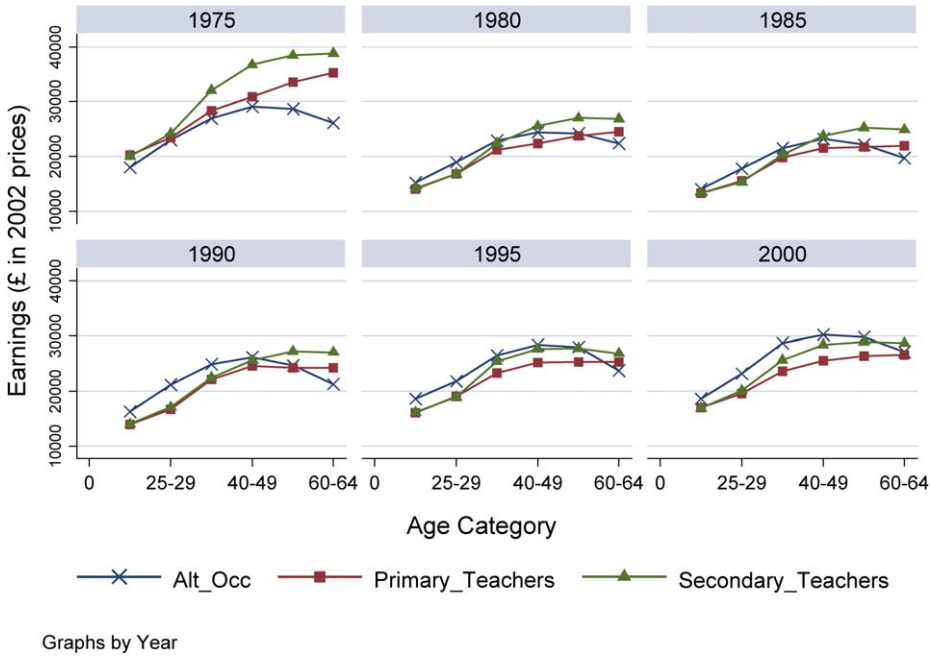


Figure 15. UK relative teachers' wages. *Source*: Own calculations.

year the PIT and the PRT is growing but that this growth has slowed down over the last 25 years.

Having observed the trends of teacher supply in the UK and from the literature that is available on teachers, we recognize 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 15 graphs the relative earnings of teachers compared to average nonmanual earnings and national average earnings.[2] The highest relative wages were paid to teachers in the mid-1960s, followed by a considerable deterioration in the period up to 1973. There followed a 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 teachers, although of less dramatic extent than the decline of the late 1960s and early 1970s.

[2] 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 nonmanual 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 nonmanual earnings supplied by the NES, and so in Figure 3, we only display teachers' earnings relative to the nonmanual average from 1968 onwards using the NES. We estimate the position relative to nonmanual earnings for 1966 (to gauge the situation for our first cohort), by adding the average difference between the October Survey and NES estimates of teachers' earnings relative to nonmanual earnings (approximately 20 percentage points), to the October Survey estimate of the relative position for that year.



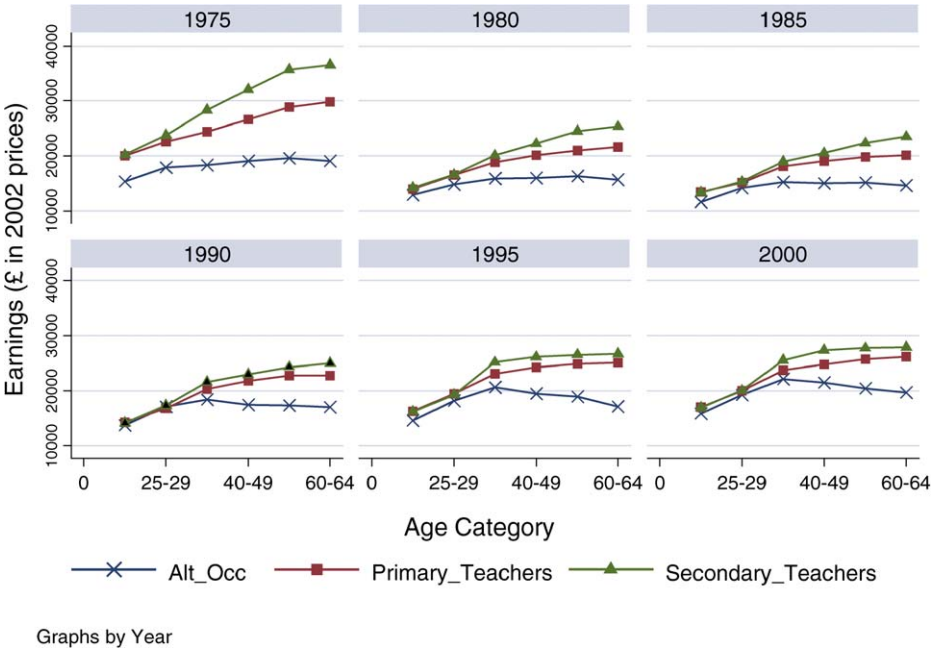
(a)

Figure 16. Age-earning profile of primary school teachers, secondary school teachers and an alternative occupation, (a) males and (b) females, 1975–2000. *Source*: DfES publications, NES and LFS.

Of course in the decision to become a teacher it is possible that the individual would consider the lifetime profile of earnings in the alternative career destinations. In Figure 16(a) we graph the average salary profile over the life cycle[3] of a male teacher and a graduate who works in an alternative occupation.[4] The figure displays the age-earning profile for males for selected years. The alternative occupation (Alt_Occ) legend represents the earnings in the alternative occupation for those with a teaching qualification who do not teach. In recent years we can see that the male nonteacher in the UK has

[3] This figure is complied from Labour Force Survey data and represents only the life-time earnings as measured in 2001 prices for teachers and other graduates based on salary data for people aged less than 25, 25–29, 30–39, 40–49, 50–59, 60–64 in each year from 1975, 1980, 1985, 1995 and 2000. They of course do not necessarily reflect what will be the lifetime earnings of those beginning their career in each year based on what they could observe people of different ages in teaching and alternative occupations earning in each of these years.

[4] Early studies of teacher salaries in the UK are Greenhalgh (1968), Conway (1962a, 1962b), Thomas (1973), Turnbull and Williams (1974).



(b)

Figure 16. (*Continued.*)

an average salary which always exceeds that of the teacher. The position is completely reversed for women as we see in Figure 16(b).[5]

Overall, in Figure 16(a), it is quite clear that the earnings of male teachers were uniformly higher than earnings in the alternative occupation in 1975. But over time, the earnings profile in the alternative occupation has been shifting up whilst that of teachers has been moving down. By 2000, it is clear that the wage in the alternative occupation is almost uniformly above that of teaching.

Additionally, the lower age categories appear to be earning a much higher level of earnings in the alternative occupation in all years after 1975, while in the later age categories, earnings from teaching exceed earnings from the alternative occupation. This gap between the older age grouped teachers and nonteachers is clear in the 1980s. However, the age-earnings profile in the 1990s and into the new century appear to indicate a slow erosion of the higher level of earnings for the older age group in teaching compared to the alternative occupation. Calculations based on these graphs indicate strongly that

[5] These life-cycle earning profiles do not cross even if we plot the teacher wage at the 90th percentile and the nonteacher wage at the 10th percentile.

males benefit financially from being in an alternative occupation compared to the teaching profession. The same analysis for women in Figure 16(b) shows that although the age-earnings profile in teaching drifts down over time, it is still above that in the alternative composite occupation. In Dolton and Chung (2004) full details of the analysis is reported. The authors show that internal rate of return to teaching has been declining for the last 25 years and is now negative for men and this means that on average men lose up to £40,000–67,000 in terms of the Pet Present Value of Earnings over their lifetime whereas women gain approximately the same relative to an alternative occupation.

The above analysis begs the question about why an individual male graduate will decide to enter the teaching profession. There are several explanations which must be borne in mind: firstly that nonpecuniary factors (like hours of work, job satisfaction and the type of vocational element to work) loom large in the individual's choice, second that the average graduate who enters teaching has a lower ability or exam performance making it less likely that they will get a nonteacher graduate job; or finally that compositional differences between the teacher and nonteacher populations regarding subject specialty, gender and other factors are the cause. We will return to these explanations in considering the theory of teacher/nonteacher occupational choice and examine the empirical validity of these explanations in the empirical econometric literature we examine.

2.4. Evidence from the rest of the world

The literature on aspects of teacher supply in the other countries in the rest of the world is large. See Macdonald (1999) for an international review of teacher attrition. There have been studies on Argentina by Vegas, Pritchett and Experton (1999), Australia by Lewis and Norris (1992), Belgium by Van den Berghe (2000), Bolivia by Piras and Savedoff (1998), Brazil by Vegas (1999), Delannoy and Sedlacek (2000) and the OECD (2001), Canada by Tremblay (1997), Press and Lawton (1999) and McIntyre (1998), Cote d-Ivoire by Komenan and Grootaert (1990), Ghana by Glewwe and Jacoby (1994), Israel by Angrist and Lavy (2001), Mexico by Nelson, Lutenbacher and López (2001) and Lopez-Acevedo and Salinas (2001), Nigeria by Abubakar (1983), Norway by Falch and Storm (2002), Bonnesronning, Falch and Strom (2003), the Netherlands by Borghans (1991), New Zealand by Gilbert, King and Cregan (2002), Oman by Al-Salmi (1994), Philippines by Acedo (1999), South Africa by Black and Hosking (1997) and Kgobe (1995), Switzerland by Wolter and Denzler (2003), Trinidad and Tobago by Premdas (1971) and Zimbabwe by Chivore (1985). Chapman (1983) provide a review for the developing countries of the world.

The single most comprehensive source of comparative information about teachers in different countries around the world is in OECD (2001). Together with the "Education at a Glance" publications from the OECD (2002a, 2002b) and earlier years it is possible to build up a picture of what has happened with teachers in different countries. These publications provide information on teacher salaries, both starting, as well as 15 years into the profession, educational expenditure, the percentage of teachers who are women,

teacher work hours, educational personnel as a percentage for the labor force, instruction time by subject. In addition much of this information is available across primary, lower secondary and upper secondary school sectors.

Data of the kind we have examined for the USA and the UK relating to pupil numbers, teacher numbers, teacher wages and other factors relating to teacher supply are difficult to obtain on a consistent basis for most other countries for any reasonable time series.[6] Hence, in order to understand what is happening across countries we turn to an examination of evidence from a cross section of OECD countries data. Until now we have explored the evidence relating to the different aspects of the teacher labor market in the UK and USA over time over the whole post war period. 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.[7]

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 easily observed. This is an inevitable shortcoming in the data set 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.

Our task is to explain the variation in teacher's salaries across different countries by relative supply and demand factors having controlled for the basic cross country heterogeneity which can be observed. In the OECD data there is information on teacher: starting salaries, salaries after 15 years, and salaries at the top of the professional pay scale for the Primary, Lower Secondary and Upper Secondary levels in the education system. All this data is presented in terms of indexed purchasing power parity in US dollars and are therefore directly comparable. From this information it is possible to derive relative teachers pay compared to GDP per head and teachers pay per hour. Dolton and Marcenaro-Guiterrez (2004) discuss all these different possible dependent variables of interest. Here we report only their results for the last two, most interesting, variables.

The data which is available from the OECD "Education at a Glance" publications allows us to construct a panel data set relating to 1995, 1996, 1998, 1999, 2000 and 2001.[8] For most of these years up to 35 countries are observed. At the maximum this gives us in our unbalanced panel data set of 425 observations (i.e., 35 countries, times 3 education sectors times 6 years minus missing values). However, for some variables not all years are observed. This means that our resulting panel data is unbalanced. In this data basic characteristics of the educational system are observed (or derived).

[6] Waterreus (2003) plots age/wage profiles in teaching and nonteaching for 7 countries France, Germany, US, UK, Sweden, Australia and the Netherlands for men and women separately.

[7] The data is available for countries which participated in the WEI Project. This project was carried out by the OECD and UNESCO, with the support of The World Bank.

[8] There are unfortunately no data for 1997 published by the OECD.

In the endogenous growth literature the relationship between education and growth has been extensively examined. The relationship between teacher supply and economic growth is therefore one of interest [see Tamura (2001)]. We measure the nature of the country's investment in education by the level of educational expenditure as a fraction of GDP and we control for the rate at which a country is growing, since clearly this will constraint its choice set of educational investment possibilities. The relative supply of teachers is measured by the number of teachers (and other educational staff) as a fraction of the labor force and the student–teacher ratio in the education system. An additional supply factor relates to the composition of the teacher stock in terms of the proportion of teachers in the country who are women. We also control for the number of teacher hours supplied in the country, as obviously fewer teachers can compensated for by a lower number of teachers working more hours. The changing nature of the demand for teacher services is proxied for in this data by the demographic growth in the size of the population of school age. In addition we are able to control for the salary differences in the three education sectors: primary, lower secondary and secondary schools.

We also collected data to try to control for the quality of educational output – by using results on the PISA tests – and the relative importance of science and mathematics in the curriculum of each country – by using the fraction of time spent on these subjects in the curriculum. The suggestion here is that since there is a relative shortage of teachers in these subjects in most schools then this might show up in the relative earnings of teachers if the fraction of time devoted to science and mathematics was higher. In the event neither of these two variables were significant in our regressions and since they reduced our sample size somewhat further we have omitted these results.

Table 1 presents the regression estimates of the aggregate factors that have an impact on the teachers salaries (expressed in PPP) relative to GDP per head and average teachers' salaries per hour in primary education, lower secondary education and upper secondary education. It shows the results of two different specifications for each of the two different dependent variables, those obtained by using OLS on the whole data and random effects when treating the data as a panel.

Looking at the table as a whole there are some clear indications that the relative supply of teachers, as measured by the stock of teachers in the labor force, has a clear effect on teacher salaries in the intuitively sensible way – that it to say – the greater the potential supply, the lower will be teacher's earnings. Likewise the pupil–teacher ratio has a supply effect which is picked up in the OLS results but not significant when the data is recognized as a panel. On the demand side it appears that as the stock of school age children grows then this demand push will factor into higher teacher wages per hour – although not into higher teacher's wages relative to GDP per head.

Further evidence of the influence of supply factors is present in the significance of the percentage of teachers who are women for both of the dependent variables under consideration. This variable has a negative impact on teachers' salaries. This may result from the possibility of gender wage discrimination or from the occupational segregation which takes place in most countries where teaching is still regarded as predominantly a female occupation. Alternatively, it may be a consequence of the different career pro-

Table 1
Estimation explaining the variation in teachers' salaries across 35 countries from 1995–2001

Variables	Teachers wage/GDP per head				Teachers wage per hour			
	OLS		Random effects		OLS		Random effects	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Constant	1.1302***	0.272	1.5344***	0.5833	32.8512***	6.4504	25.9023**	12.3274
Teachers and educational staff as a fraction of the labor force (%)	−0.1917***	0.0451	−0.2908***	0.1075	−3.2530***	1.0246	−2.1446	2.4813
Teaching hours per year	0.00003	0.0002	0.0003	0.0003				
Women fraction of teaching staff (%)	−0.0073***	0.0024	−0.0018	0.0027	−0.5717***	0.0545	−0.2796***	0.0523
Lower secondary dummy	0.1083	0.0662	0.1579***	0.0605	−0.4816	1.5716	2.5731**	1.1642
Upper secondary dummy	0.1413	0.0811	0.2533***	0.0866	−1.7056	1.9602	5.2414***	1.6747
GDP growth (%)	−0.0098***	0.0019	−0.0089***	0.0016				
GDP per head					0.0014***	0.0001	0.0009***	0.0001
Expenditure on educational institutions as a percentage of GDP	0.2452***	0.0355	0.1617*	0.0893	6.1510***	0.9495	4.1793**	1.9743
Student–teacher ratio	0.0287***	0.0045	0.0085	0.0059	0.0921	0.1326	−0.0443	0.1330
Growth in the size of the population at the age of primary/lower secondary and upper secondary education (%)	0.0001	0.0030	0.0035	0.0039	0.2415***	0.0626	0.1071	0.0755
Number of observations	425		425 in 30 countries		388		388 in 30 countries	
F-statistic	26.35				89.29			
R-squared within			0.118				0.4011	
R-squared between			0.471				0.7659	
R-squared overall	0.349		0.327		0.646		0.6289	

*Coefficient significantly different from zero at 10% confidence level.
**Coefficient significantly different from zero at 5% level.
***Coefficient significantly different from zero at 1%.

motion prospects faced by the male and female teachers in the various countries that we examine.

With our two different dependent variables we must be careful how we control for the relative wealth of a country and the effect of economic growth. When using the teacher's wage relative to GDP per head we can clearly only control for economic growth and not the absolute size of the wealth in the country. However in the teachers wage per hour equation we must control for this absolute wealth effect although this will limit the specification to exclude growth in GDP. This specification strategy will hopefully allow us to assess the importance of wealth in explaining teachers' salaries in the different countries.

The results relating GDP growth to teachers' relative salaries compared to GDP per head indicate that there exists a negative relationship between the changing wealth of a country and their teachers' salaries. This may be due to the rate at which an economy grows is largely determined by the productivity of the private sector. Those countries which have private sectors which are growing more rapidly are more likely to be leaving their public sector workers behind – in relative pay terms. Looking at the teacher pay per hour results we find that the wealthier a country is (as measured by GDP per head) the more likely they are to pay their teachers more per hour. As expected, any increase in the expenditure on educational institutions (as a percentage of GDP) has a significant and positive effect on teachers' salaries.

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 have positively significant coefficients when the panel models are estimated suggesting that when cross country heterogeneity is accounted for then there is some evidence that teachers in lower or upper secondary schools are paid up to 15% or 25% more, respectively, than their primary school counterparts.

The overall goodness of fit of these estimated equations is reasonable with around 32–35% of the variation in teacher's wages relative to GDP per head explained and 62–65% of the variation in teachers wages per hour explained. This indicates that the included variables have a reasonable 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).

3. Modeling teacher supply

A variety of theoretical econometric models have been used to estimate aspects of teacher supply. The OECD (2002a, 2002b) report on teacher supply is careful to distinguish the different components of a satisfactory explanation of teacher supply. These would include: an explanation of the choice of training to be a teacher by those eligible, the initial occupational choice and entry into the profession, what conditions whether an individual leaves or stays in the job and the length of duration in the job, and who returns

to teaching after an interruption to working in the job. Additional supply considerations are the hours of teaching and nonteaching time an individual teacher chooses to supply and whether the individual will be absent from work on any specific day. Finally, how can individual's teachers supply decisions be aggregated to provide a national picture about aggregate supply?

This section starts with a simple characterization of the aggregate market in diagrammatic terms before examining, in some detail, the models which have been used to model individual training and occupational choice, entry to the job, exit from the job and duration in the job.

3.1. A simple model of the aggregate teacher labor market

In the Zabalza, Turnbull and Williams (1979) model of the labor 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 larger class sizes then it could cut the demand for teachers immediately by increasing its desired pupil–teacher ratio. Since in many countries the current political climate puts pressure on governments to cut class sizes and improve SAT 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. The supply of teachers is the focus of this chapter.

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 qualified 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 labor market opportunities, and varying relative nonpecuniary conditions of work. To a certain extent, some of these factors can be controlled by the government (or federal authorities), 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 nonpecuniary 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 labor to teaching [Kyriacou and Coulthard (2000)].

We now outline a simple model of the labor market for teachers, illustrating how a situation of excess demand (or insufficient supply) can arise. Following Zabalza, Turnbull

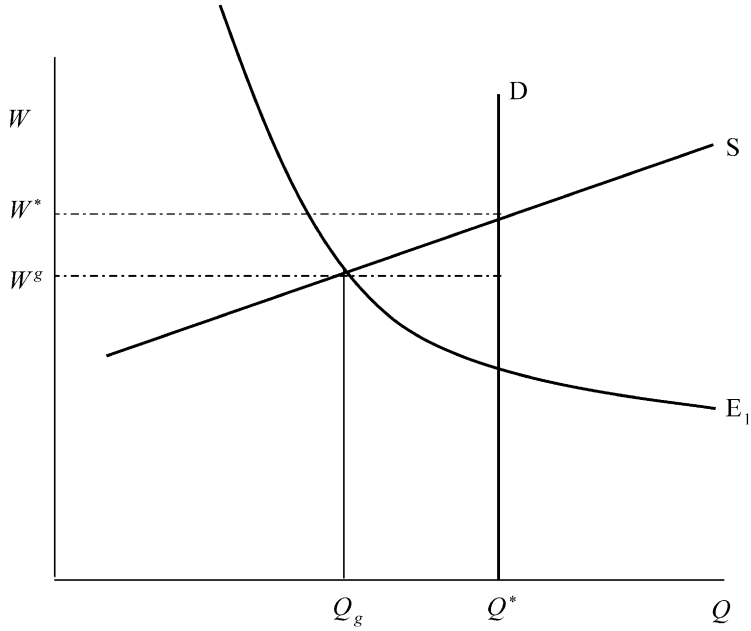


Figure 17. The labor market for teachers.

and Williams (1979), the labor 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 labor.[9]

The demand for teachers can 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 17. Under the reasonable assumption that the supply of teachers is a positive function of average teacher earnings, an upward-sloping labor supply schedule can be drawn as S. In a perfectly competitive market, a teacher wage of W^* would therefore clear this labor market. However, the teachers' labor market is of course not competitive, and the government, in its role as (almost) exclusive purchaser of teaching labor, has other considerations, prime among 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, labeled E_1 in Figure 17; 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^{g}, and the excess demand for teachers is $Q^* - Q_{\mathrm{g}}$. This can only be eradicated by a relaxing of the budget

[9] The private sector in most countries accounts for no more than 5–7% of all teachers hired.

constraint leading to higher earnings, or other factors changing to make teaching more attractive, so that more potential teachers supply their labor at any given wage.

Of course, the above analysis is simplistic in that it treats all teachers as being the same. In reality, within the same country, there may be teacher shortages in particular geographical locations or regions or in particular subjects, with an over-supply elsewhere. In addition, the real market position is very different for primary and secondary school teachers. We can amend Figure 17 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 among potential teachers. In addition, there are of course other conceptual problems with the simple concepts of supply and demand which have be used in the literature [see Zabalza, Turnbull and Williams (1979) for a discussion].

3.2. Initial occupational choice models

In this section we review the basic static model of occupational choice as applied to the initial decision to become a teacher. This model is taken from Zabalza (1979a, 1979b), Willis and Rosen (1979) and Dolton (1990). The basic form of this model is that the individual is assumed to be making the choice of becoming a teacher or not when teaching is compared to the best of the other alternative occupations. Let regime A refer to those who make the choice of becoming "a teacher" and regime N models the behavior of those who choose "not to become a teacher". In the basic Willis and Rosen model it is assumed that earnings streams in two occupational regimes may be parameterized by a simple geometric growth process. The model can then be written out formally.

To consider the model in detail it is necessary to examine the individual's choices. If individual i chooses to enter teaching after graduation then his expected earnings stream is

$$\begin{cases} W_i^{\mathrm{a}}(t) = 0, & 0 \leqslant t \leqslant T_i^{\mathrm{a}}, \\ W_i^{\mathrm{a}}(t) = W_{si}^{\mathrm{a}} \exp\bigl[g_t^{\mathrm{a}}\bigl(t - T_i^{\mathrm{a}}\bigr)\bigr], & T_i^{\mathrm{a}} \leqslant t \leqslant \infty, \end{cases} \tag{1}$$

where T_i^{a} is the fixed period of postgraduate teacher training for individual i, W_{si}^{a} is the starting salary on commencing work after T_i^{a} months, and g_i^{a} is the per period growth of earnings of the individual i in group A. Notice that salary at any time $W_t^{\mathrm{a}}(t)$ is assumed to be a function of the length of service $t - T_i^{\mathrm{a}}$, and the growth of earnings.

If individual i chooses not to enter teaching then the individual may, or may not, enter vocational or academic postgraduate study after graduation, prior to taking a job. The expected earnings stream for a nonteacher is

$$\begin{cases} W_t^{\mathrm{n}}(t) = 0, & 0 \leqslant t \leqslant T_i^{\mathrm{n}}, \\ W_t^{\mathrm{n}}\bigl(t, T_i^{\mathrm{n}}\bigr) = W_{\mathrm{si}}^{\mathrm{a}} \exp\bigl[g_t^{\mathrm{n}}\bigl(T_i^{\mathrm{n}}\bigr)\bigl(t - T_i^{\mathrm{n}}\bigr)\bigr], & T_i^{\mathrm{n}} \leqslant t \leqslant \infty, \end{cases} \tag{2}$$

where T_i^{n} is the period of full time study to be chosen by individual i, $W_{\mathrm{s}i}^{\mathrm{n}}$ is the starting salary on commencing work after T_i^{n} months, and g_i^{n} is the per period growth of earnings of the individual i in group N. Notice that salary at any time is assumed to be a function of T_i^{n}, as is initial renumeration and the growth in earnings. If the individual has made a rational decision the human capital model would predict that $W_t^{\mathrm{a}}(t)$, $W_{\mathrm{s}i}^{\mathrm{n}}$ and g_i^{n} would be increasing functions of T_i^{n}.

The present value of earnings for individual i in group A is

$$V_i^{\mathrm{a}} = \int_{T_i^{\mathrm{a}}}^{\infty} \left[W_i^{\mathrm{a}}(t) \exp(-r_i t) \right] \mathrm{d}t. \tag{3}$$

The maximum present value of earnings, chosen over alternative investment periods for any individual i in group N is

$$V_i^{\mathrm{n}} = \operatorname*{Max}_{T_i^{\mathrm{n}}} \int_{T_i^{\mathrm{n}}}^{\infty} \left[W_i^{\mathrm{n}}\left(t, T_i^{\mathrm{n}}\right) \exp(-r_i t) \right] \mathrm{d}t, \tag{4}$$

where it is assumed that the choice of the full time study months investment by individuals is rational. Denote this optimal choice by $T_i^{*\mathrm{n}}$. One important problem with the choice of T_i^{n} is that most courses are of a fixed duration e.g. one year. This creates problems in any model which assumes continuous investment possibilities in T_i^{n}. Rather it is convenient to acknowledge that T_i^{n} may only be available in discrete lumps and assume for modeling purposes that each graduate has rational expectations of future earnings (and earnings growth) with different levels of T_i^{n} and makes the choice which maximizes his present value of future earnings.

Assume that a person i chooses not to go into teaching if $V_i^{\mathrm{n}} > V_i^{\mathrm{a}}$. Defining $I_{1i} = \ln(V_i^{\mathrm{n}} / V_i^{\mathrm{a}})$ and substituting from Equations (1) and (2) into (3) and (4) would give[10]

$$I_{1i} = \ln W_{\mathrm{s}}^{\mathrm{n}} - \ln W_{\mathrm{s}}^{\mathrm{a}} - r_i\left(T^{*\mathrm{n}} - T^{\mathrm{a}}\right) - \ln\left(r_i - g^{\mathrm{n}}\right) - \ln\left(r_i - g^{\mathrm{a}}\right). \tag{5}$$

One consideration which has been overlooked in this simple model is the possibility that graduates entering different occupations may face different employment prospects. Zabalza (1979a, 1979b) and Zabalza, Turnbull and Williams (1979) raise this possibility and explicitly introduce the probability that having trained for a job a graduate may be unemployed for a period of time – which may be different in different jobs. Let the per period probability that a trained teacher finds a job be π^{a}, then the expected time until a trained teacher finds a job will be $\tau^{\mathrm{a}} = 1/\pi^{\mathrm{a}}$. Likewise the typical nonteacher will have a per period probability of finding a job of π^{n} then the expected time until they find a job will be $\tau^{\mathrm{n}} = 1/\pi^{\mathrm{n}}$. Without rehearsing all the notation presented above, it is straightforward to see that the time taken to find a teaching job after training, will now be the training time and the average waiting time, i.e., $[T^{\mathrm{a}} + \tau^{\mathrm{a}}]$. Likewise the time taken to find a nonteaching job will now be $[T^{*\mathrm{n}} + \tau^{\mathrm{n}}]$. This means we can rewrite the

[10] After a Taylor series expansion and some mathematical manipulation Willis and Rosen (1979) show.

occupational choice function (5) as

$$
\begin{aligned}
I_{1i} &= \ln W_{\mathrm{s}}^{\mathrm{n}} - \ln W_{\mathrm{s}}^{\mathrm{a}} - r_i\left(\left[T^{*\mathrm{n}} + \tau^{\mathrm{n}}\right] - \left[T^{\mathrm{a}} + \tau^{\mathrm{a}}\right]\right) \\
&\quad - \ln\left(r_i - g^{\mathrm{n}}\right) - \ln\left(r_i - g^{\mathrm{a}}\right), \\
I_{1i} &= \ln W_{\mathrm{s}}^{\mathrm{n}} - \ln W_{\mathrm{s}}^{\mathrm{a}} - r_i\left(T^{*\mathrm{n}} - T^{\mathrm{a}}\right) - r_i\left(\frac{1}{\pi^{\mathrm{n}}} - \frac{1}{\pi^{\mathrm{a}}}\right) \\
&\quad - \ln\left(r_i - g^{\mathrm{n}}\right) - \ln\left(r_i - g^{\mathrm{a}}\right). \qquad (6)
\end{aligned}
$$

Hence, we can see that the choice of entering one occupation or another will also depend on the relative probability of being offered a job in the different destinations. We will return to this expression when we consider the derivation of the aggregate supply function.

3.3. Nonpecuniary considerations and subsequent occupational choice

An important aspect of modeling an individual's decision to be a teacher is the potential nonpecuniary aspects of teaching compared to other jobs. The theory of compensating wage differentials and equalizing differences [Rosen (1986)], would suggest that individuals weight such nonpecuniary considerations as well as the pecuniary rewards in decision making. Hence the "actual wage" has components of both pecuniary and nonpecuniary rewards in jobs. Following the model suggested in Dolton (1990) we can assume that this can be captured in one parameter, μ, so that "real" earnings in teaching ω^{a}, and outside teaching, ω^{n}, are money wages, W^{a} and W^{n} respectively, weighted by the individual's perception of the nonpecuniary rewards in teaching relative to nonteaching, μ_{it} $(0 < \mu_{it} < 1)$ at time t:

$$
\omega_{it}^{\mathrm{a}}(t) = \frac{\mu_{it}}{1 - \mu_{it}} W_{it}^{\mathrm{a}}(t), \qquad (7)
$$

$$
\omega_{it}^{\mathrm{n}}(t) = \frac{1 - \mu_{it}}{\mu_{it}} W_{it}^{\mathrm{n}}(t). \qquad (8)
$$

We assume that this μ parameter is simultaneously an index measuring the characteristic "propensity to teach" which each individual has but is unknown before working and is learned and revised as the individual spends time in the labor market. For convenience we assume that prior to entry into any job any individual i has $\mu_i = 0.5$ so that nonpecuniary rewards to jobs are considered equal. After some time in the labor market the individual may modify their subjective evaluation of μ. At time t, μ_{it} could also be used to capture the difference in short term "actual earnings" of changing jobs caused by transition costs, extra training and other factors.

Assume that the individual is considering a change in occupation at time t'. Assume also that wages continue to grow at their constant rates in the two regimes so that the expected earnings stream for teachers and nonteachers are given by

$$
W_t^{\mathrm{a}}(t) = W_{\mathrm{s}i}^{\mathrm{a}} \exp\left[g_t^{\mathrm{a}}\left(t - t'\right)\right], \qquad t' \leqslant t \leqslant \infty, \qquad (9)
$$

$$
W_t^{\mathrm{n}}\left(t, T_i^{\mathrm{n}}\right) = W_{\mathrm{s}i}^{\mathrm{n}}\left(t'\right) \exp\left[g_t^{\mathrm{n}}\left(T_i^{\mathrm{n}}\right)\left(t - t'\right)\right], \quad t' \leqslant t \leqslant \infty. \qquad (10)
$$

The difference in the present value, V_{it}^{an} of future "actual" earnings of an individual who is a teacher but decides to become a nonteacher at time t' is

$$V_{it}^{\mathrm{an}} - V_{it}^{\mathrm{a}} = \int_{t'}^{\infty} \left\{ \left[\omega_i^{\mathrm{a}}(t) - \omega_i^{\mathrm{n}}(t) \right] \exp(-r_i t) \right\} \mathrm{d}t. \tag{11}$$

If $V_{it}^{\mathrm{an}} - V_{it}^{\mathrm{a}} > 0$ the individual who started in the labor market as a teacher will change his occupation at time t'. The corresponding expression for the present value of earnings of individuals who were nonteachers but considering a change into teaching at time t' is

$$V_{it}^{\mathrm{na}} - V_{it}^{\mathrm{a}} = \int_{t'}^{\infty} \left\{ \left[\omega_i^{\mathrm{n}}(t) - \omega_i^{\mathrm{a}}(t) \right] \exp(-r_i t) \right\} \mathrm{d}t. \tag{12}$$

3.4. Modeling using cross-section data

Using equation (6) a Taylor series approximation to the nonlinear terms around their population mean yields a "reduced form" determination of the I_{1i} as a function of the independent variables in (6). Therefore the statistical representation of I_{1i} may be written as

$$I_{1i} = \delta_0 + \delta_1 \left(\ln W_s^{\mathrm{n}} - \ln W_s^{\mathrm{a}} \right) + \delta_2 \tau^{\mathrm{n}} + \delta_2 \tau^{\mathrm{a}} + \delta_2 g^{\mathrm{n}} + \delta_2 g^{\mathrm{n}} + X_{1i} \beta_1, \tag{13}$$

where X_{1i} measures the postgraduate training variables and includes a vector of other relevant exogenous variables and cannot be observed directly but the decision by each individual concerning his or her preferred regime is recorded. The implication of this decision criteria is that the individual will make the choice of whether or not to become a teacher on the basis of comparative salaries, their expected earnings growth and the employment prospects in the different regimes.

There are inevitably clear problems in reconciling the theoretical model described above with the data which is usually available for the econometric modeling of the teacher decision. There are many econometric problems with such estimation procedures.

One of the most difficult problems in the modeling of a system of equations is obviously that of determining which variables can be regarded as exogenous in order to ensure identification via exclusion restrictions. Typically relative wages and previous occupation choices are endogenous variables in the current occupational choice decision. Most importantly to identify the decision equation we have to find exclusion restrictions which are factors which influence occupational choice but do not influence the earnings and earnings growth equations. In practice this means finding regressors for the determination of occupational choice which are exogenous to the determination of wages. In many datasets this will be a difficult task. This means that (at least) two stage estimation procedures are required to derive consistent estimates of these variables in order to use their predicted value in a second (or subsequent) stage of estimation. Commonplace in econometric models of this kind is to employ the Willis and Rosen (1979)

type structural model combining both earnings determination, earnings growth and occupational choice into a simultaneous structure. This is the procedure adopted by Dolton (1990).

A second and related problem that has received a lot of attention in the economics literature in the issue of sample selection bias. The problem directly affects our ability to estimate a model relating to one group in the population when entry into that group is determined in a way which is not unrelated to the original dependent variable we wish to explain. For example, estimating an equation for teachers only when teachers as a group may be a nonrandom subset of the population will lead to biased estimates of the coefficients in the relevant equations. Hence in modeling teacher earnings equations we would first need to make the appropriate corrections for the fact that the sample observed earning wages as teachers are only those who have chosen to be teachers and that such a decision may be related to the wage prospects on offer in teaching relative to other jobs. Care must therefore be exercised in attempting to model the correlations between the relevant structural equations.

A related problem plagues the estimation of an equation relating to the occupational choice of women when the choice is only being observed for those women who are participating in the labor market. Hence this means that a teacher choice equation needs to be jointly estimated in a bivariate probit model to allow for the simultaneity of the occupational choice and participation decisions. Such a model is estimated by Dolton and Makepeace (1993). A more complete econometric representation of this problem would require the dynamic modeling of the women's occupational choice and participation decision jointly with fertility and even marital decisions.

An associated important problem is that the theory relies on a comparison of the lifetime earnings in different regimes. Naturally it is only possible to approximate the earnings of any individual in the regime chosen. This presents us with the problem of how to estimate the foregone earnings in other regimes which will influence an individual's investment decision. The approach adopted in Dolton (1990) was adapted from Willis and Rosen (1979). It suggested using a structural model of the joint decision to enter teaching with the determination of earnings and earnings growth in the teaching and nonteaching regimes. From these equations the predicted level of earnings and earnings growth that a teacher would have got in nonteaching and a nonteacher would have got in teaching are predicted. This then enables us to estimate the equation relating to the teacher/nonteacher decision via the use of the predicted wage differential terms included as regressors.

3.5. Duration modeling and exit from teaching

A natural corollary of the modeling of the occupational decision at any specific point in time is to model the length of time someone stays in a given labor market state. This is possible if the econometrician has available to them panel data which tells them what state the person occupied at various points in time. Alternatively if we have good retrospective data from a survey which asks when the respondent changed labor market state

we may also model the duration of time in the state. This is of particular importance in studying the market for teachers as we wish to know how long people stay in teaching, what state they exit to (i.e., is it another job outside teaching or is it to household production) and what influences the timing of these decisions.

A commonly used econometric model for this problem is to analyze the duration of the stay in teaching as a continuous time reduced form proportional hazard specification with unrestricted baseline hazard:

$$h_i(t) = \underline{h}(t) \exp\{X_i(t)'\beta\}, \tag{14}$$

where $\underline{h}(t)$ is the baseline hazard at time t, $X_i(t)'$ is a vector of possibly time dependent explanatory variables for individual i at time t and β is a vector of unknown parameters. In many cases the explanatory variables will include the relative earnings in the two destinations of teaching and nonteaching. This basic model, or variants of it have been used by Dolton and Van der Klaauw (1995a, 1995b), Brewer (1996), Stinebrickner (1998a, 1998b) and Van den Berghe (2000) to model the duration of stay in the teaching occupation. An important generalization of this model involves the using of a competing risks specification to allow the possibility of exit to several different labor market states. Dolton and Van der Klaauw (1999) and Stinebrickner (2002) use this model to consider the exit of women teachers to either other jobs outside teaching or directly into household production.

The econometric problem which has received the most attention in the duration data literature is the modeling of the presence of unobserved heterogeneity. That is to say that there are influences on the dependent duration variable which are not captured in the measured regressors available to the econometrician. If unobserved heterogeneity is present but erroneously the model specification assumes it absent then the estimated parameters may exhibit erroneous negative duration dependence. The models of duration in teaching estimated by Dolton and Van der Klaauw (1995a, 1995b, 1999) explicitly model this unobserved heterogeneity both in a Gamma form and in the nonparametric way using mass points.

A second important problem in the estimation of duration models for teacher job duration is that of the most appropriate specification for the baseline hazard. The models of duration in teaching estimated by Dolton and Van der Klaauw (1995a, 1995b, 1999) explicitly model this baseline in a variety of ways. The most appropriate specification turns out to be that of the flexible baseline hazard estimated nonparametrically for each month or each quarter. When estimated using this method the baseline hazard reveals the distinctive pattern of job tenure, which exhibits clearly defined spikes for the periods which coincide with school term ends and academic year ends. Indeed, the use of any other modeling assumption on the baseline hazard can understandably be shown to be a model misspecification as clearly the institutional nature of the restrictions imposed on possible lengths of job tenure by the duration of school years and academic terms requires the use of the flexible baseline hazard. This is clearly another example of a situation in which the correct econometric model yields new insights into the economic

structure of the data to be explained and where use of the wrong technique would give rise to biased results.

Modeling the exit from teaching should undoubtedly distinguish between the different types of reasons for leaving teaching. Most importantly, a women leaving teaching for family reasons is quite distinct from one leaving teaching to enter a job in a different sector. Modeling job durations by different types of exit is most often estimated using the independent competing risks framework which assumes that the underlying error structure for each type of exit is independent of each other type. A new departure in this literature is to recognize that the reason for exit from teaching for one reason may not be independent of the latent variable of the time to exit for another reason. Such a model of dependent competing risks estimation is estimated by Dolton and Van der Klaauw (1999).

3.6. Dynamic models and uncertainty

So far in our discussion we have assumed that the individual makes a decision to enter a job in the initial period, or leave a job in a subsequent period, based on a single calculation relating to the wage and nonwage benefits as calculated at the time the decision is being made. In reality, the decision maker will not know the wage on offer in the alternative careers with certainty or their growth into the future.

One simple model of occupational choice with uncertainty is presented by Flyer and Rosen (1997). In this model, which essentially attempts to capture this crucial feature of the teacher labor market, it is suggested that the individual faces the choice between a low variance earnings occupation (teaching) and high variance earnings occupation. They show that there is an increasing propensity to choose the high variance occupation as θ increases (where θ is the time devoted to work). This result is consistent with results found by Polachek (1981) which suggests that female dominated occupations have lower human capital depreciation rates.

The static occupational choice model in the previous section is myopic in its assumptions about individual decision making because it assumes: that current period decisions do not affect the utility of future decisions and that current period decisions do not influence the state variables that will affect the utility that the person receives from the different available alternatives into the future. For example the acquisition of an extra year's experience in teaching now could affect the future wages in teaching since it may affect promotion and advancement prospects.

More complex models which attempt to capture the dynamic nature of the career decision process for teacher entry and exit have been suggested by Van der Klaauw (1997), Stinebrickner (2001a, 2001b) and Csellack (2002) based on dynamic programming models adapted from other the occupational choice literature [Miller (1984), Siow (1984)], or other applications in economics [Eckstein and Wolpin (1989)]. A further important complication which we have so far ignored is the possibility that the individual may not wish to work in any career at various points in their life cycle to be primarily engaged in home production. We can now introduce this possibility into the theoretical

framework. We follow closely the exposition of Stinebrickner (2001a, 2001b) as it is most directly relevant to our concern to model the supply of teachers.

Let W_{it}^{j} and Z_{it}^{j} represent respectively the wage and nonwage utility of person i at time t for some employment option j. Let $j = A, N, H$, where A denotes the teaching alternative, N the nonteaching alternative career and H the household production alternative,

$$U_{it}^{j} = W_{it}^{j} + Z_{it}^{j}. \tag{15}$$

Assume that the individual is assumed to know their current utility associated with each option but that they do not know the utility of each option in the future. Hence we assume that both W_{it}^{j} and Z_{it}^{j} are partly determined by stochastic factors which represent the randomness in wage and nonwage utility (respectively) of each person in each option into the future.

The value function of an option, which depends on the person's state variables, can be written as

$$V_{it}^{j} = U_{it}^{j} + \beta E \max\left[\left\{V_{it+1}^{j} \mid d_{it} = j\right\}\right], \tag{16}$$

where β is the discount rate, E is the expectation operator, and the set $\{V_{it+1}^{j} \mid d_{it} = j\}$ includes the value functions associated with the set of available options for the person in the next period, $t + 1$, conditional on the choice at time t, d_{it}, being equal to j.

In principle this model is sufficiently general to allow the econometrician to consider modeling a panel data set of individuals entering and leaving teaching and nonteaching jobs or engaging in home production throughout their working lifetime. The use of the dynamic model of teacher choice requires detailed panel data in which the participation and occupational choice are observed at each point in time.

3.7. The aggregate teacher supply function and time series models

It is relatively straightforward to derive [see Zabalza (1979a, 1979b) for formal details] an aggregate time series model of teacher supply directly from the simple microeconometric model set out in Section 3.2. In this framework (in which only monetary factors condition decisions) then it is possible to show that a direct consequence of the decision rule (16) is that there exists an individual specific reservation relative wage ζ such that for each person in the eligible labor force (L) such that if the wage is below this level the person becomes a teacher and below it they become a nonteacher. Out of a possible total potential labor force L, the proportion selecting $A(L_a/L)$ will be given by those whose reservation wage is less than, or equal to, the market relative wage; that is $P(\xi \leqslant W_a/W_n)$. Given a distribution of the reservation wage in the population, the proportion choosing to enter teaching will change if the relative wage on offer changes. This aggregate supply function will also change as the relative employment prospects in the alternative occupations change, the reservation wage changes and the discount rate changes. We can write this basic aggregate supply function in the following simple

form

$$\frac{L_a}{L} = S\left(\underset{+}{\frac{W_a}{W_n}}, \underset{+}{\pi_a}, \underset{-}{\pi_n}, \underset{+}{r}, \underset{-}{\xi}\right). \tag{17}$$

Variants of this aggregate teacher supply function have been estimated by Thomas (1975), Zabalza (1979a, 1979b), Zarkin (1985), Court, Reilly and Williams (1995), Dolton, Tremayne and Chung (2003) and others.

Such aggregation ignores: regional disparities in pupil–teacher ratios, the deployment of teachers as opposed to the total numbers and the overall total level of unfilled vacancies, ad hoc temporary or part time supply teacher arrangements and the substitution of untrained teachers into specialist subjects. Obviously the huge variation indifferent the demand for different subjects also complicates the position.

A structural form model of the aggregate working of the teacher labor market over time would have the determinants of market supply and market demand in its structural equations and be estimated using time series data. A commonly used reduced form of such a model is written in terms of a market adjustment equation describing how movements in relative earnings change with the changing level of excess demand. This equation was first suggested by Arrow and Capron (1959) to model the market for scientists. It has been used to model the market for teachers by Dahlby (1981), Zabalza (1979a, 1979b), Dolton and Robson (1996) and Bee and Dolton (1995). Such a "Market Adjustment Equation" has the form

$$rw_t - rw_{t-1} = g(ED_{t-1}, X_t) + u_t, \tag{18}$$

where excess demand, $ED_{t-1} = (d_{t-1} - s_{t-1})$, where d_{t-1}, s_{t-1} are respectively demand and supply in period $t-1$, rw_t is the average relative wage of teachers at time t and X_t are the set of exogenous variables affecting demand or supply at time t.

In its simplest form the market adjustment model is a naïve specification with regard to the implicit assumed perfect market structure. In practice the public sector demand for teachers predominates and several authors have been concerned to model the role of monopsony power in the market. Research by Dahlby (1981) in the UK found some support for the monopsony model with supply elasticities ranging from 0.20 to 0.75. A later paper by Luizer and Thorton (1986) has been concerned to measure the concentration of the monopsony power over local education authority boundaries, claiming that previous, more naive, measures of monopsony which ignore concentration, are flawed.

3.8. Government and manpower planning models

Manpower planning models were developed in the 1960s and 1970s in response to the need of governments to model the flows of workers into and out of occupations and forecast the need for qualified manpower into the future. Such models were extensively used by governments in various countries to model the demand for and supply of teachers. For early expositions of the operation and application of these models see IBE/UNESCO (1967), Hansen (1966), Ahamad (1970, 1973), Edmonston and

Knapp (1979), Williams (1975, 1979), Denton, Feaver and Spencer (1994). The statistical theory of the most sophisticated versions of these models are well described in Bartholemew, Forbes and McClean (1991). The manpower planning model is still the basis of the government's model for the teacher labor force in the UK, see DES (1965, 1990), DfEE (1997, 1998).

The demand for teachers in these models is calculated by using the available figures on pupil numbers and desired pupil–teacher ratios. This will give a crude estimate of the required number of teachers to staff the existing school system under various assumptions. This demand calculation may be made more complex by allowing for subdividing the aggregate demand into demand for teachers into primary school teacher and secondary school teacher demand and examining the demand for teachers of different subjects and factoring into the calculation the regional variations in the population of school children or the enrollment rate trends. Other factors which may be brought into the calculation are: the size of the existing stock of qualified teachers who are trained but not yet employed, the numbers who may return to the job after a household or family break, any changes in the structure of the school day, class size or teaching load or conditions of work. In any year, to compute the required additional demand for new teachers it is also necessary to model the rate of retirement and resignations from the existing stock of teachers.

In the manpower planning context the supply of teachers is modeled using a formal model of the process described in Figure 1. This involves estimating the number of teachers who are in service in any year and into the future by modeling the process of entrance, re-entrance retirement and wastage from the profession. This includes modeling the process by which those who are being trained as teachers either enter the workforce or drop into the pool of inactive teachers, PIT on graduation. It also involves establishing which teachers from the PIT are in fact likely to return to teaching – i.e., are really in the pool of recoverable teachers, PRT. Again such modeling can become fairly complex, if it takes into account the demographic age structure of the existing teacher workforce and the pattern of wastage by gender and age which may operate. Further complications arise if the differential demand by geographical region is considered or the primary or secondary balance is taken into account and the existing subject specialist stock of teachers is considered.

In general, the manpower planning approach is to collect as much data on the exogenous factual variables, like pupil numbers by age, existing numbers of teachers by age, gender, sector and subject, as possible, then making the most appropriate use of this data make assumptions about the existing set of relationships between variables – by extrapolating from, for example, recent wastage trends and retirement rates into the future. This technique allows the planner to forecast the demand for and supply of teachers into the future. It must be stressed that such forecasts will only be relevant estimates of the future state of supply and demand if the assumptions used to generate the prediction are reliable. By and large these models are fairly deterministic and do not usually ascribe any role to economic variables like relative teacher salaries. The excess demand/excess supply figure (Figure 11) relating to the UK was constructed using the most basic form

of a manpower planning model as it relied on the existing stock of serving teachers as an estimate of supply and the fulfillment of the government's target pupil–teacher ratio as the driver of demand when pupil numbers are given exogenously. Although the calculation is naïve – it does – nevertheless provide a basic benchmark for the determination of pattern of shortage or surplus over the last 40 years.

3.9. Other models

Surprisingly in a consideration of teacher supply there are relatively few studies which actually model the conventional labor supply hours of work decision for teachers. This is because – for the most part – teachers have little scope to choose their hours of work as the school day is fixed in terms of length and the school terms are already set prior to the individual choosing to become a teacher. Two exceptions to this are when we consider the decision to be a part time or full time teacher or if we consider the pattern of teacher absence as part of the labor supply decision. Waterreus and Dobbelsteen (2001) have considered the former and Lindeboom and Kerkhofs (2000) have considered the latter. We need not rehearse the standard labor supply model in order to discuss their contributions as this is available elsewhere [see Blundell and McCurdy (1999)].

4. The determinants of teacher recruitment, turnover, retention, mobility and re-entry

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 factors that influence the decision to enter teaching, and those that influence the decision to exit from teaching. The key explanatory variable in most of these studies is the wages that teachers receive, and thus this review will concentrate on these results. Since the empirical literature is so large we will focus attention on those studies which report the most important econometric results. Our approach will be to summarize the details of these key studies in Table 2 and focus on the qualitative conclusions in the exposition. Other factors will however be mentioned where appropriate. In particular we will attempt to draw out a synthesis of conclusions relating to studies which assess the effect on teacher supply of: school and subject differences; conditions of work and career structure; and female work patterns. Inevitably many studies cross over these different factors in teacher supply so we will only discuss them in the section which relates to their major findings.

It is inevitable that many studies in the literature on teacher supply consider the quality of teachers and the relationship between teacher inputs and pupil outcomes. A part of this literature also considers the possibility that other methods of payment for teachers, like merit pay, or performance related pay may affect teacher performance or pupil outcomes. We do not consider any aspects of this literature. These studies are the subject of a separate chapter in this volume.

Table 2
Summary of selected applied econometric articles on teacher supply

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
I. Entry and staying decision					
Manski (1987)	Entry	2952 respondents from the National Longitudinal Study of the High School Class of 1972, who gain a degree, and are in work in October 1979	Estimate probit of occupation choice, as a function of sex and academic ability. Estimate weekly earnings equation as a function of sex, academic ability and occupation, corrected for selection into occupation	Use the results to predict the proportion of the cohort who enter teaching, and their average ability. $25 increase in weekly earnings (about a 10% increase), raises the supply of teachers from 19% to 24% of the cohort. $100 increase in weekly earnings (about a 40% increase), raises the supply of teachers from 19% to 44% of the cohort. Thus wage elasticity of supply ranges from 2.4 for small salary increases to 3.2 for large changes	Average ability of supply of teachers barely changed by these wage increases (since both high and low ability individuals are attracted). A $25 per week increase, together with a minimum. requirement of 800 on SAT tests, would maintain the supply of teachers at 19% of the cohort, while raising average academic ability to the national average for college graduates
Dolton (1990)	Entry and staying decisions	UK, 1980 Graduate Cohort, information for 1980–1987 on 4,982 graduates, of whom 633 chose teaching as a first job	Probit on decision to become a teacher 4 stage modeling. Reduced form probit on becoming a teacher, and then staying a teacher. Use selectivity terms in teacher, nonteacher wage equations, finally use predicted earnings in structural form for entry decision probit and continuation probit	Relative nonteacher/teacher starting wages, expected wage growth for teachers and nonteachers. Nonteacher starting wages relative to teacher starting wages and expected nonteacher wage growth have significant negative effect on probability of becoming a teacher, while expected teacher wage growth has significant positive effect. Higher current predicted non teacher earnings relative to predicted teacher earnings has a significant negative effect on whether currently a teacher (7 years in)	Include predicted decision whether to become teacher upon graduation as a regressor in current job equation. Significant positive effect – suggests importance of first occupational decision or nonpecuniary factors

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Dolton and Makepeace (1993)	Choice of participation in the labor force and choosing teaching as a career	UK, 1980 2,056 female graduates	Bivariate probit of participation and teacher occupational choice with selectivity corrections	Finds significant relative earnings effects on the choice of occupation. A rise in the relative earnings of teachers from 1970 to 1990 increases the proportion who would choose teaching by 8.2%	Finds that the participation decision and the decision to enter teaching are endogenously related. Typically women choosing careers in teaching are partly doing so because it is a compatible career with household production
Hanushek and Pace (1995)	Probability of being in a teacher training program	USA, 1,299 graduates	Probit estimation of the probability of teaching	Participation in teacher training is not significantly affected by relative teacher earnings	Potential teachers perform lower on tests that other graduates and teacher training completion is lowered by state requirements for courses and teacher tests

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Dolton and Mavromaras (1994)	Staying in teaching	UK, 1970 and 1980 Graduate Cohorts, providing information for 1970–1977 and 1980–1987. Usable samples sizes equal to 3,990 and 4,980	Probit on decision to continue as a teacher. 4 stage modeling. Reduced form probit on becoming a teacher, and then staying a teacher. Use selectivity terms in teacher, nonteacher wage equations, finally use predicted earnings in structural form for entry decision probit and continuation probit	Predicted nonteacher minus teacher-log earnings. Significant negative effect on probability of continuing as a teacher for both males and females. A 10% rise in relative teacher earnings would increase probability of currently being a teacher by 9.67% for 1970 men, 1.37% for 1980 men, 3.03% for 1970 women and 2.38% for 1980 women. 12% (32%) of 1970 men (women) choose teaching – would fall to 6% (16%) if facing 1980 conditions. 7% (25%) of 1980 men (women) choose teaching – would rise to 18% (32%) if facing 1970 conditions. The average man is 5% more likely to become a teacher in 1970 than in 1980. Due entirely to deteriorating market conditions – characteristics of 1980 men actually more favorable to teaching than those of 1970 men. Similarly, women are 8% more likely to teach in 1970 than in 1980, almost all of which is due to market conditions (favorability of characteristics barely changed)	Men's current decision to be a teacher more strongly influenced by original occupation choice than for women

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Dolton and Kidd (1995)	Entry into different career destinations including teaching	UK, 1980 male and female graduates	Multinomial logit estimation with endogenous wage determination	Finds relative wage effects are important in career choice	Simulations suggest that if men had chosen "like" women more of them would enter teaching. Likewise if women had chosen like men more of them would have entered the private sector
Flyer and Rosen (1997)	Linked to entry into teaching	Female college graduates in 1979–1991 NLSY, with less than 18 years education, who worked 500 hours in any year after graduation, and earned hourly rates between \$3 and \$50 (1990 \$'s)	Estimate log wage growth equations, including time spent out of the labor force and its interaction with teacher status	Fall in wage growth equals to 10% per year out of the labor force. However, offset completely by out of labor force – teacher interaction. Female teachers do not suffer wage penalty for time out of the labor force that other women suffer. May make teaching more attractive to family-orientated women	Results are not typical of other female-dominated occupations. Interaction term insignificant for both nurses and administrative, support – suggesting these occupations suffer the usual wage penalty for time out of labor force
Chevalier, Dolton and McIntosh (2006)	Entry and staying in teaching	UK, 1960, 1970, 1980, 1985, 1990 and 1995 cohorts of graduates surveyed 6–11 years after graduation	Sample selection correction on earnings from the reduced form probit decision to be a teacher	Relative wages in teaching have a significant impact on the likelihood of graduates choosing to teach. Impact depends on the cohort and changes over time	School exam performance, subject of degree, class of degree, postgraduate qualifications, type of school, parents occupation, region, and gender all have a significant effect on the entry decision. Cross-cohort simulations suggest that wage effect on the supply of teachers is strongest at times of low relative teacher's earnings

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
II. Exit decision					
Zabalza, Turnbull and Williams (1979), Chapter 6	Exit	UK, Time series, 1963–1972. 8 observations per year, defined by age groups	OLS	Relative wages defined as above (replacing subject specific with age specific earnings in the first case). Elasticity of trained graduate separation rate, with respect to relative wages is −2.4 to −3.0 for men, and −0.6 to −0.7 for women. Elasticity of trained graduate separation rate with respect to relative starting wage is −2.6 for men and −0.7 for women, and with respect to the relative growth in earnings is −1.2 for men and −0.1 for women	
Rumberger (1987)	Percentage of teacher shortages and turnover of Maths and Science teachers by district	USA, 346 school districts from 1983–1984	OLS	Salary differentials between teachers and alternative occupations influence teacher shortages	The basic relationship is influenced by gender and geographic area
Eberts (1987)	Exit from teaching	USA (New York), 7,714 individuals working as full-time teachers in 1972–1975, taken from Personnel Files	Logit estimation	Difference between actual and predicted salary not significant in separation probability	Finds union negotiated contract provision sand class size limitation provisions reduce the probability of separation in unionized districts

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Theobald (1990)	Exit from district (may still be teachers elsewhere. Can't distinguish vol/invol, perm/temporary)	USA, all certified teachers in Washington state (37,000), 1984–1987	Probit	Salary per day that they should receive next year. Significant negative for men in all years. Significant negative for women in some years. Prospective earnings 10% above the mean leads to a 6.9% fall in the probability of leaving	Outside options captured by qualifications. Teachers with Masters degree 35% more likely to leave (doctorate; 40%). Only significant for men
Rees (1991)	Exit (if leave to teach in another district of New York, treated as end of first spell)	USA (New York), 49,396 individuals working as full-time teachers in 1975–1976, taken from Personnel Files	Logit model on separations.	Current salary. Significant negative effect on quits. Predicted probability of separations, at different salary levels: 0.097 at $13,000, 0.075 at $16,400, 0.057 at $20,000	Teachers with higher educational attainments (measuring outside opps) are significantly more likely to quit
Beaudin (1993)	Returning to teaching after an interruption	USA (Michigan), 3,060 teachers in 1972–1975	Logit model	Those teachers least likely to return are those with better paying employment outside schools	Teachers most likely to return are those with subject specialties. Females return in higher proportions than males. Those who interrupt at a younger age and with higher qualifications are less likely to return

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Gritz and Theobald (1996)	Stay in teaching	USA (Washington), 9,756 white teachers who began teaching in 1981–1990. Followed until 1992	Generalized transition probability model	Finds significant salary effects in the probability of staying in teaching but these diminish with experience	Examines the teacher decision to teach in the same school district and the considers the role of inter-district mobility. Finds that expenditure and resources at the district level can impact on teacher stay
Theobald and Gritz (1996)	Exit from first teaching post, to a teaching post in another Washington school district, or out of teaching altogether	USA (Washington), 9,756 white teachers who began teaching in 1981–1990. Followed until 1992	Multinomial logit	Annual salary paid to teacher. Raising salaries reduces probability of exiting school system, and increases probability of remaining within teaching if they do exit. Raising all teacher salaries by $3000 decreases the proportion of females leaving education system in 10 years from 59% to 54% (males 31% to 23%). Of those leaving, the proportion transferring to another school within state increases from 28% to 33% for women and from 49% to 53% for men	Average earnings in county has positive, mainly insignificant effect on leaving. A $3,000 fall in outside wages leads to a fall in proportion of teachers leaving profession over 10 years, from 59% to 57% for women, and from 31% to 30% for men

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Hanushek, Kain and Rivkin (1999)	Exit (includes changing school district) and quality	USA. Texas Schools Project database – a matched panel of entire cohorts of students and all teachers. Use 1993–1996 data	Linear probability models for exit. OLS and IV for quality	Base year salary. Negative, and significant for teachers with up to 5 years experience. A 10% increase in starting salary is associated with a 2% decrease in the probability of leaving for probationary teachers (0–2 years of experience) and a 1% decrease for those with 3–5 years of experience. Note, when include district fixed effects, salary effect becomes insignificant (in contrast to Murnane and Olsen studies above). Maybe insufficient salary variation across small time span	Quality effects: 1. Effects of starting salary on a teachers' test scores (at district level): Salary coefficient insignificant. Split by district size – salary has positive and significant effect on teacher test scores in districts that hire at least 7 new teachers – a 10% rise in starting salary in such districts increases district average test score by 5 percentiles. Maybe larger districts make better use of enlarged applicant pool. 2. Effects of starting salary on change in student test scores. When use IV for measurement error on starting salary, and include student fixed effects, salary effect is positive and significant. A 10% increase in starting salaries raises maths achievement by 0.17 standard deviations, and reading achievement by 0.11 standard deviations. Note, not affected when control for turnover, and effect is larger where there are no probationary teachers – suggests salary effect works through motivating existing teachers

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
III. Duration of stay in teaching					
Murnane, Singer, Willet (1989)	Time spent in teaching	USA (North Carolina) teachers hired between 1976–1978	Hazard function estimation	Find that higher than average salaries induce lower than average leaving hazard	Underlying hazard of leaving declines with the length of service. Found evidence of higher hazard for those with higher examination scores and subject specialty differences
Murnane and Olsen (1989a, 1989b)	Time spent in teaching (includes movement within the state but not outside the state)	USA (Michigan Statist. Dept.) of Education on all teachers who began teaching in 1972–1975, followed through to 1985	Estimate probability density function for duration of continuous teaching spell	Annual salaries teachers earned (or would have earned if they had stayed in teaching in the same district), expressed in 1967 dollars. Significant negative effect – stay longer in teaching if paid more. An increase of \$1,000 in 1967\$'s in each step of salary scale is associated with an increase in median length of teaching spell of greater than 4 years	Salary effect 1/3 smaller if exclude district fixed effects (assume fixed effects pick up bad working conditions, that are positively associated with salary through compensating differentials). Include opportunity cost, as salary paid to graduates who participate in subject training. A \$1,000 increase in opportunity cost salary (in 1967\$'s) reduces median length of teaching spell by 4 years

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Murnane and Olsen (1990)	Time spent in teaching (includes movement within the state but not outside the state)	USA, 13,890 white teachers who began teaching in North Carolina public schools between 1975 and 1984	Estimate probability density function for duration of continuous teaching spell	Annual salaries teachers earned (or would have earned if they had stayed in teaching in the same district), expressed in 1987 dollars. Significant negative effect – stay longer in teaching if paid more. An increase of $1,000 in 1967$'s in each step of salary scale is associated with an increase in median length of teaching spell of 2–3 years, for teachers who started teaching in 1975. Influence then falls in later years (effect half as big for those starting teaching in 1979) – perhaps due to declining student enrollments making teachers wary about getting back in to teaching if they leave	No significant interaction effect between salary and subject specialty. Influence of salary 30% less for teachers with National Teachers Exam (NTE) score in the top quartile (viewed as indicator of ability and ease of getting job elsewhere, rather than measure of teacher effectiveness). Salary effect 35% smaller if exclude district fixed effects (assume fixed effects pick up bad working conditions, that are positively associated with salary through compensating differentials)
Dolton and Van der Klaauw (1995a)	Duration to exit from first continuous teaching spell (i.e., maybe across different jobs).	UK, 1980 Graduate Cohort. Uses information for 1980–1987 on 923 graduates who chose teaching as a first job	Hazard model of length of first teaching spell	Relative wage – predicted difference in log of teacher and nonteacher graduate earnings at each month of experience. Elasticity of the hazard with respect to the relative wage equals to −1.5 (higher relative teacher wages reduce the probability of leaving). A 10% rise in teacher relative earnings reduces exit probability at 5 years' tenure by 9% (retention rate after 5 years increases from 66% to 69%, and to 73% if a 25% rise in relative wage)	Teachers with a B.Ed. have a lower probability of leaving teaching

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Mont and Rees (1996)	Time to exit (if leave to teach in another district of New York, treated as end of first spell)	USA (New York), 525 individuals newly hired as grades 9–12 teachers in the fall of 1979, followed through until 1987, taken from Personnel Files	Discrete hazard model on length of teaching spell	Starting salary in 1979$'s. Significant negative on hazard of exiting teaching job. A 10% increase in starting salary lowers attrition rates by about 6%	Finds that probability of exit is higher for teachers with higher class load characteristics and below average quality of students. Also finds evidence of median household income effects in the district
Brewer (1996)	Exit (if leave to teach in another district of New York, treated as end of first spell)	Panel of teachers newly hired in 1978 and followed through to 1989, from New York State Dept. of Education data	Discrete time hazard model on length of spell in teaching	Current salary, in 1980$'s. Negative effect on probability of quitting, but significant only for women. Include mean salary of newly appointed educational administrators, and number of such positions in district created per year (represents pinnacle of career). Administrators wage has negative effect on probability of quitting, significant only for males (more likely to get the post). Number of posts has insignificant effect. A 10% increase in district administrator salaries reduces quit probability by 0.3%	Include county mean teaching salary relative to teacher's own salary as measure of outside opportunities. Increases quit probability for men and women. Dividing male new hires into new entrants and re-hires, effects of own salary and administrators' salary are significant only for new entrants. Interacting wage effects with length of spell, effect of district administrators' salaries and number of administrator posts opened becomes greater (more negative) with length of spell, while effect of own salary becomes smaller (less negative) with length of spell

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Stinebrickner (1998a, 1998b)	Exit from first continuous teaching spell (i.e., maybe across different jobs)	USA, National Longitudinal Study (NLS) of the High School Class of 1972. Followed for 14 years. Use data on 341 certified to teach between 1975–1985	Hazard model of length of first teaching spell	Log weekly wage. Significant negative effect – higher wages increase the length of first teaching spell. Probability that a person with a wage 1 standard deviation above the mean will stay in teaching more than 5 years is 9% higher than the probability that a person with the mean wage will stay in teaching	Opportunity cost captured by degree subject. Teachers with a science degree are significantly more likely to leave
Dolton and Van der Klaauw (1999)	Duration to exit from first continuous teaching spell, and reentry to teaching after leaving	1980 Graduate Cohort. Info for 1980–1987 on 6,098 graduates, of whom 923 chose teaching as a first job	Hazard model of length of first teaching spell. Competing risks of exit into nonteaching job or nonemployment allowed for. Also, hazard model for length of time spent out of teaching	Predicted earnings in teaching, at each level of experience. Significant negative effect on hazard of leaving to nonemployment (large but not significant effect on nonteaching employment hazard). Uniform 10% increase in teacher salaries will raise percentage of teachers still teaching after 5 years from 66% to 69% (equal reductions in numbers going into nonteaching employment and nonemployment). Positive effect (almost significant) on hazard of returning to teaching. A uniform 10% increase in expected teacher salary reduces percentage of former teachers who do not return within 4 years from 41% to 37%	Also include predicted earnings in nonteaching employment, at each level of experience. Significant positive effect on exit to nonteaching employment (but not nonemployment) and significant negative effect on hazard of returning. 10% increase in expected nonteacher earnings reduces percentage still in teaching after 5 years from 69% to 62%, and increases percentage who do not return within 4 years from 41% to 44%

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Van den Berghe (2000)	Staying in teaching	Belgium, 50,041 administrative records of teachers between 1973–1996	Proportional hazard Model. Weibull and nonparametric baseline	Finds a significant but very small effect of increased wages in teaching increasing the hazard of men leaving teaching. Wages have no effect for women	Finds that increasing workload, part time work and centralized decision making increase the leaving hazard but that if the individual works in several schools this reduces the hazard
Stinebrickner (2002)	Duration, exit	USA, NLS 1972, 422 female teachers	Duration Competing Risks with exit to nonteaching job and out of the labor force. Flexible baseline hazard	Wage coefficients have negative sign suggesting that individuals are less likely to exit to nonteaching or OLF if their teaching wage is higher	Finds that there is a very large positive effect of leaving teaching on nonteaching option with the birth of a new baby
IV. Dynamic programming model of stay in teaching					
Van der Klaauw (1997)	Entry and mobility	USA, NLS of the High School Class of 1972. 2,940 high school graduates. Followed for 14 years	Dynamic utility maximization model of occupational choice and occupational mobility estimated by Maximum likelihood. Model accounts for first and subsequent choice and nonpecuniary aspects of the decisions	Estimated model could be used to evaluate the effectiveness of several policy experiments designed to improve the composition and quality of the teacher labor force	Finds that teacher salaries and opportunity wages are important determinants of the supply and retention of teachers

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Stinebrickner (2002)	Entry and exit	USA, NLS of the High School Class of 1972. 22,652 high school graduates. Followed for 14 years. Use data on 450 certified to teach between 1975–1985	Estimate wage and nonpecuniary utility equations for teaching and nonteaching. Maximum likelihood estimation, estimating coefficients on characteristics to make the labor force choices that we actually observe most likely (as individuals evaluate wages and nonpecuniary utility from different options)	Simulation. Calculate individuals' value functions, given their characteristics and the estimated coefficients, then change wages, via 1 of 2 policies. Policy 1: 25% pay increase for all teachers Policy 2: on average, a 25% pay increase, but depending linearly on teachers' SAT scores. Proportion of time spent in teaching increase from 0.48 to 0.72 under both policies more choose to teach initially and those that do stay longer, particularly the former – therefore greatest effect on males. Both policies reduce time in nonteaching rather than time out of workforce – therefore again, greatest effect for males	Interaction with SAT scores. Ratio of time spent in teaching among high ability relative to low ability is 0.88 (0.44:0.50). Under policy 1, this ratio increases to 0.94, and under policy 2 to 1.11 (i.e., policy 2 more successful in attracting high ability teachers)
Csellack (2002)	Teacher occupational choice by year	USA, NLSY 1979. 1,839 individuals from 1979 to 1998 of whom 276 chose teaching as an occupation	Dynamic structural model of occupational choice	Simulates the effect of wage policies on teacher supply. Finds that a 2% increase in teacher's wages increases teacher supply by 2.6% but has no effect on the ability of those choosing to be teachers	Considers the effect of marriage, fertility college major and post graduate study on the teacher decision

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
V. Time series studies of aggregate supply relative wages and excess demand					
Thomas (1975)	Relative supply as measured by the Proportion of Graduates entering teaching	UK time series 1962–1970	OLS	Find significant salary effects suggesting a 1% fall in relative starting salaries will induce a 2–5% fall in the relative supply of male graduates entering teaching and similar effects for average salaries of teachers. Effects for female graduates are up to twice as big	Find for male graduates that the unemployment to vacancy ratio for administrative, technical and professional workers is positively significant for male graduates but not female graduates
Zabalza, Turnbull and Williams (1979) Chapter 5	Entry	UK time series, 1963–1971. 5 obs per year, defined by numbers of teachers in 5 subject groups	OLS	Relative teacher wages (compared to subject specific salaries from NES, or average annual earnings of nonmanual workers). Elasticity of graduate new entrants with respect to wage equals to 2.4–3.9, depending on definition of alternative wages, for men, and 0.3–1.8 for women (prefers higher estimates based on average earnings of all nonmanuals). Also, look at relative starting wage, and relative growth in wages. Elasticity of graduate entrants with respect to relative starting wages is 3.4 for men and 2.8 for women, while elasticity with respect to relative growth in earnings is, 1.6 for men and 0.4 for women. Therefore wage effects greater for men primarily because of their consideration of career prospects	Split results by degree subject (sciences and arts). For men, wage elasticity is greater for arts than for science students (insignificant for latter), while for women the reverse is true

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Dahlby (1981)	Shortage of school teachers	UK time series 1948–1973	OLS using a dynamic adjustment model on changes in relative wages	Number of students entering teaching is related to wage adjustment	Uses the data to argue that the monopsony model explains the shortage of teachers
Zarkin (1985)	Numbers completing teacher training	USA time series from 1950–1979 on teacher enrollment data	OLS	NA	Finds an important role for future demand conditions in the supply of graduates entering teacher training
Lewis and Norris (1992)	Supply and demand for teachers	Australia, time series data from 1972–1989 for Western Australia	No formal estimation	NA	Discusses the role of market forces in shaping supply and demand for teachers in Australia
Bee and Dolton (1995)	Teachers relative pay	UK 1956–1998 time series	OLS	Finds evidence of higher salaries link with excess demand for teachers	Links the time series evidence with the cross-section evidence to suggest the importance of excess demand in the determination of relative wages in cross-section data
Dolton and Robson (1996)	Teachers relative pay	UK 1956–1990 time series	OLS	Finds evidence of higher salaries link with excess demand for teachers	Finds that higher teacher union concentration of membership is positively related to teacher relative pay

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Court, Reilly and Williams (1995)	Relative supply as measured by the Proportion of Graduates entering teaching	UK 1986–1992 using time series data	OLS	Find significant salary effects suggesting a 1% fall in relative starting salaries will induce a 4% fall in the relative supply of graduates entering teaching	Find additional effects for the subject mix and proportions of women reading social science and language degrees. Do not find any evidence of unemployment or salary progression effects
Dolton, Tremayne and Chung (2003)	Teacher supply as proxied by various variables	UK time series data from 1947–2000	OLS using time series stationarity tests	Find that teacher supply is countercyclical. Evidence that supply is higher if graduate unemployment and relative wages are more favorable. Also find differences in the strength of effects by gender. Men are much more likely to be affected by aggregate conditions than women	Use different measures to proxy for teacher supply – wastage rates, changes in the size of the PIT and fractions entering the profession from all graduates in a given year
VI. Other studies					
Antos and Rosen (1975)	Earnings	USA, 5,454 teachers from a 5% sample from 1965 Equality of Educational Opportunity Survey	OLS	NA	Examined the spatial distribution of teachers based on the theory of equal advantage. School characteristics, racial composition, intelligence of students and neighborhood hazards are found to be important in wage variation. Estimates an increment of at least $300 would be required to get the average white teacher into the average black teachers school

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Edmonston and Knapp (1979)	Teacher aggregate supply and demand	USA, time series from 1934–1978	Demographic manpower model	NA	Uses a manpower planning model projecting pupil, teacher and new teacher numbers and fertility rates to project demand and supply for teachers. Predicts an over supply of teachers in the USA in the late 1970s
Denton, Feaver and Spencer (1994)	Demand and supply of teachers	Simulation	Dynamic simulation	NA	Simulation experiments investigate the changes in fertility rates on supply and demand for teachers. Results suggest that teacher imbalance is found to be highly volatile in response to fertility variations
Ballou and Podgursky (1998a, 1998b)	Quality	None	Simulation, using estimates of entry and exit behavior from other studies	Increase salary by 20%. Share of teaching workforce in top 5% of SAT scores increase from 5% to 7.6%. Most still have SAT scores below the college graduate average. If a high weight is put on attracting high ability (greater chance of them getting job) then 9.0% of workforce are high ability (top 5% of SAT distribution)	Problem is higher wages reduce exit rates, reducing number of vacancies, thus putting off people from training, esp. those with good alternative options (i.e., high ability). If the 20% salary increase is restricted to top 2 levels of ability, get 9.2% of workforce as high ability (similar effect to giving all teachers the raise, and targeting high ability, but of course cheaper)

Table 2
(*Continued*)

Author (Year)	Dependent variable	Country/Sample	Estimation method	Wage effect	Other comments
Lindeboom and Kerkhofs (2000)	Duration of absence from teaching job	Holland, 4,969 teachers in 426 schools with 21,137 spells of absence in 1987–1991	Mixed proportional hazard, partial likelihood, nonparametric baseline hazard with fixed school effects		Teachers are more likely to be absent: if they are very young or old, if they teach lower or small groups, if anticipated replacements are difficult or unanticipated replacements less difficult and if they are on permanent contract rather that a part time contract
Waterreus and Dobbelsteen (2001)	Hours of work in the labor supply equation	Holland, 1324 Dutch Secondary school teachers in 1998	OLS and IV. Endogeneity of net wage is corrected by using gross hourly wage and household income as IVs	Wage elasticity of supply at average weekly hours worked (33.48) is 0.24, i.e. to induce a teacher to supply 34 instead of 33 hours a week a 13% increase in salary is required. Male wage elasticity is 0.19 and female is 0.39	Simulation suggests that 3.5 million guilders would need to be spent on teachers wages to increase the number of hours by 8%. Whereas they suggest a full time premium would produce some effects for only 0.5 million guilders
Gilbert, King and Cregan (2002)	Earnings of teachers	New Zealand, 125 teachers observed 20 years after graduation	OLS	40% of the wage differential cannot be explained by experience, qualifications and mobility an hence attributed to discrimination and unobservables	

4.1. Overview of the market and sources of supply

At the beginning of this chapter Figure 1 detailed the potential sources of teacher supply. At the outset in the determination of teacher supply we must be interested in the numbers who enroll in teacher training as this is the source of potential teachers. There are relatively few studies of what determines entrance into teacher training. In several studies in the USA, Hanushek and Pace (1994, 1995) examine the decision of college students to enter teacher training or not. They use the NLSY High School and Beyond survey from 1980–1986. They find that potential teachers perform lower on tests than other graduates and teacher training completion is lowered by state requirements for courses and teacher tests. They suggest that would be teachers are less likely to complete their qualification if the state imposes a pre-specified cut-off on a standardized test (national Teacher's Examination). They also suggest that students are less likely to complete their training in states which require their trainee teachers to complete a large number of education related courses. Their results suggest that teacher salaries do not have an important influence on student choices. Although the relative earnings of teachers compared to all college graduates varies considerably across different states in the US, they do not have a significant impact on the decision to enter teacher training.

There is a limited amount of evidence of a time series nature relating to the pattern of what influences initial teacher training recruitment. Zabalza (1979a, 1979b), using time series data for the UK over the 1963–1971 period, examines entry into teacher training by faculty of degree. He finds that relative wages and graduate unemployment have an effect on entry. Higher relative wages and higher unemployment induce higher rates of entry into teaching. This work has been brought up to date by Dolton, Tremayne and Chung (2003) who also find evidence of the importance of unemployment and relative wage effects in the initial teacher entry decision as modeled by entry to teacher training. They model entry into teacher training by faculty of study over the time period 1960–2000.

A further source of supply are the teachers that are created under crisis "emergency certification" measures which are, from time to time, instituted to ease the crisis in teacher supply. Examples of these measures have been used in the UK over the period 1960–1970, and at various times since, when graduates and those with suitable levels of experience were considered for short term training courses. Other such schemes have been introduced in various US states at different points in time. Little or no evaluation of how well these teachers work out or how long they stay in the profession has been conducted.

Another source of potential supply is to encourage part time working of those ex-teachers who are considering a return to work but may be constrained by family and other obligations. HMSO (1994) explicitly examines part time and returning teachers into the profession in the UK. It suggests that more could be done to make provision for part time and returning teachers to be able to adapt to the changes in the school curriculum and ensure that part time staff had improved lines of communication with full

time staff. It also suggests that supply problems could be alleviated by more effective job share arrangements.

4.2. *Aggregate labor market conditions, government intervention and the market mechanism*

An early study, based only on time series data at the average aggregate level in the UK for the years 1963–1971 by Zabalza, Turnbull and Williams (1979), estimates the elasticity of the supply of labor into teaching, 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 of their consideration of career prospects.

As with the entry into teaching decision, Zabalza, Turnbull and Williams (1979) also undertake a time series analysis of the exit decision, considering the years 1963–1972. Dolton and Mavromaras (1994) find that males are much more likely to be influenced by the wage rates on offer 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, Turnbull and Williams (1979) find that this gender differential in wage effects exists for both starting wages and the growth in wages.

Chevalier, Dolton and McIntosh (2001, 2006) overview the market position for teachers in the UK from 1960 to the 2002 using graduate cohort data from six separate cohorts of university graduates. The use of this data allows them to simulate the effect of possible teacher pay rises over time. They find 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 on the market situation at the time. The wage effect on the supply of teachers is strongest at times of low relative teachers' wages, or following a period of decline in those wages. It is also strongest for those individuals who have more recently graduated. For example, increasing wages of teachers by 10% would have led to an increase of nearly 10% in the supply of teachers in the mid-1980s but only 2% in the mid-1960s or early 1990s.

Labor market conditions at the time the occupational choice is made are also important. The most recent evidence from Dolton, Tremayne and Chung (2003) looks at time series data over the whole post war period in the UK and finds that aggregate labor market conditions, particularly unemployment levels, are important determinants of teacher supply. They use various different proxies of teacher supply including the wastage rate from the profession and changes in the size of the pool of inactive teachers. They find that the supply of graduates to teaching is counter-cyclical with most graduates' perception of teaching (and willingness to enter the profession) improving when teacher

pay is high compared to alternative occupations and when graduate unemployment is high.

4.3. Earnings, relative pay and the opportunity wage

Most of the empirical work on teacher supply that has been published has focused on the role of salary, and most specifically, relative salaries in teaching in an econometric explanation of those who decide to initially become teachers, and those who subsequently decide to stay in teaching. Naturally higher relative salaries are a possible way of offsetting poor working conditions in a compensating wage type explanation of the relative attractiveness of the teaching profession. In this section and in Table 2 we review the most important contributions to this literature.

There are a small number of US studies to have considered the entry decision into the teaching profession. One of the first significant contributions to have used an econometric approach to teacher supply is the contribution of Manski (1987). He uses data from the National Longitudinal Survey of the High School Class of 1972. The results of his probit equation on occupational choice (teacher/nonteacher) suggest a 10% increase in weekly teaching earnings will raise the supply of teachers from 19% to 24% of the graduate cohort. Moreover, a 40% increase in weekly teaching earnings raises the supply of teachers to 44% of the cohort. Thus the elasticity of teacher supply ranges from 2.4 from small salary increases, to 3.2 for larger increases. Manski also considers the quality aspect, and in particular is concerned by the fact that the average ability of those who choose teaching is below the average among all college graduates, quality or ability being measured by SAT scores. He suggests that a general pay increase does not improve teacher quality, since both low- and high-quality teachers are increasingly attracted to the profession. However, Manski 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 among that group to the national average for college graduates.

Other early cross-section evidence of the importance of teacher salaries as a determinant of the decision to stay in teaching was provided by the papers of Murnane and Olsen (1989a, 1989b, 1990). Their results suggested that those teachers who have the highest salaries stay in teaching longer and those with the higher opportunity cost – as measured by test scores and degree subject – stay in teaching for less time.

Considering the entry decision, British work on this topic is limited. Dolton (1990) uses data from the 1980 Graduate Cohort, which follows 4,982 graduates for up to seven years after they have graduated. The paper suggests that it is the relative level of teachers' wages, rather than the absolute level, that affects the decision whether to become a teacher. In order to test this hypothesis empirically of course requires estimates of alternative earnings in jobs that individuals did not choose, as well as data on actual earnings received in whatever job graduates choose to do. In order to obtain estimates of alternative earnings, Dolton estimates wage equations for each of the possible cases (teacher

and nonteacher), to derive an estimate of earnings for each individual in their nonchosen state.[11] Similarly, wage growth equations are also estimated in both states, so that estimated wage growth in the nonchosen state can be compared to actual wage growth in the chosen state. The results are very much as expected, in that 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 nonteachers. The other variables in the equation suggest that, among the individual characteristics, belonging to an ethnic minority, and having parents of a higher social class, are both associated with a lower probability of becoming a teacher. As expected, individuals with degrees in education are more likely to become teachers than those individuals with degrees in other subjects. The results also reveal something about the quality of graduates who decide to become teachers, since individuals with a higher class of first degree, who went to university instead of a polytechnic, and who hold a PhD are all, on average, less likely to become teachers. This quality effect is over-and-above the simple fact that the high-achievers at degree level can earn more in nonteaching occupations, since alternative wages are controlled for.

One important problem in the econometric estimation models which were reviewed in the previous section was the difficulty of identifying the precise nature of wage effects. In a simple static choice framework, under restrictive assumptions, we saw that we could reduce the problem of choice to a consideration of starting salaries and the growth in earnings. Typically we do not have good data on earnings growth in teaching and nonteaching or indeed on a more general rate of return to becoming a teacher compared to the rate of return of having an alternative career. Hence what little evidence there is on this is important. Wilson (1983) shows that there has been a declining rate of return to becoming a teacher over the 1962–1979 period in the UK. The paper follows the method of Birch and Calvert (1973) by simply calculating a rate of return based on national salary data for teachers. Such a task requires good cross-section data on a country wide basis over many years. In addition it also really requires the equivalent data for nonteachers in order to make a valid comparison about what has happened to the relative rate of return in teaching and alternative occupations. A recent paper by Dolton and Chung (2004) addresses these issues by comparing teachers life time earnings with those of people who are qualified to teach but do not do so. They find in computing rates of return for men and women over the 1960–2000 period that the rate of return in teaching has been falling for both genders over this time period but that teaching is still a relatively good job for women compared to the alternative available to those who are qualified to teach but do not do so. In contrast, teaching has a negative rate of return for men over the nonteaching alternative.

There are many more studies examining the decision to exit from teaching. This is presumably due to the existence, particularly in the US, of administrative data sets

[11] Note that the wage equations were corrected for selectivity into the chosen state.

containing information on large numbers of teachers, allowing the "quitters" to be compared to the "stayers". 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 selectivity term controlling for those who became teachers in the first job after graduation attracts a positive and significant coefficient, suggesting that the original choice has a strong influence on later choices, which may be caused by inertia and the transition costs of moving jobs or a persistent effect of attractive nonpecuniary benefits associated with teaching.

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 among teachers. Each uses data on 923 1980 graduates who chose teaching as their first job, following the individuals for seven years after their graduation. The econometric model used analyses the factors associated with the "hazard" of leaving this job. As in the Dolton (1990) paper, a lot of attention is given to the role of relative wages, with wage equations again being estimated to provide the relative wage variable, measured as the predicted difference in the log of teacher and nonteacher graduate earnings at each month of experience. The results show that the elasticity of leaving a teaching job with respect to this relative wage measure is about -1.5, suggesting a large reduction in quit behavior among teachers, following a rise in earnings. For example, a 10% rise in teachers' relative earnings is estimated to increase the retention rate after five years from 66% to 69%, while a 25% rise in relative earnings would further increase this retention rate to 73%. The importance of the outside labor 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, if they hold a noneducation first degree, if they are from a higher social class and if they attended an independent school. In addition, those teachers who claim that they only entered teaching because they could not find more suitable work are, not surprisingly, more likely to leave teaching in the following years, presumably as more appropriate work becomes available.

Dolton and Van der Klaauw (1995b, 1999) extend their earlier (1995a) work by adopting a "competing risks" approach to their hazard rate modeling. In particular, they allow the explanatory variables to have a differential impact on the likelihood of leaving for nonteaching work, and the likelihood of leaving the labor force altogether. The fact that a large proportion of teachers are women, who are more likely to leave the labor force in order to raise a family, could make such a distinction appropriate. The results show that this is indeed the case. Specifically, a higher teaching wage reduces the probability of teachers leaving the labor force altogether, while a higher predicted wage in the

nonteaching sector is related to an increased likelihood of moving into a nonteaching job. The individual characteristics identified as having a significant impact on teacher turnover in the Dolton and Van der Klaauw (1995a) paper, are shown to work specifically through their impact on the probability of leaving the labor force altogether, and have a much smaller effect on the likelihood of moving into alternative employment, with the exception of the effect of having a professional postgraduate qualification, for which the reverse is true.

Turning back to the US literature on the exit decision, the evidence closest in spirit to the UK studies using the graduate cohort data sets is provided in two papers by Stinebrickner (1998a, 1998b, 2001a, 2001b), using data from the National Longitudinal Study of the High School Class of 1972. The two papers follow a small number of individuals who chose teaching as their first job (341 and 450 respectively) over the period 1975–1985. The earlier paper estimates a hazard model of the duration of this first teaching job. As was found with the UK studies, teachers are more likely to stay in their job, the higher are the wages that they receive. Stinebrickner estimates that a teacher earning one standard deviation above the mean teaching wage will have a 9% higher probability of staying in that teaching post more than five years. The Stinebrickner (2001a, 2001b) paper is interesting, in that it follows a different strategy to all other papers in this area. Essentially, he estimates wage and nonpecuniary utility equations for both teaching and nonteaching. The coefficients are maximum likelihood estimates, chosen so that it is more likely that we observe individuals in the occupation (in this case teaching or nonteaching) that they actually choose, on the basis that individuals are more likely to choose the occupation in which their predicted wages and nonpecuniary benefits are highest. Given an individual's characteristics and the estimated coefficients, the author can then predict whether that individual will become and remain a teacher, and can simulate 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 time, that the initial teachers spend in teaching, rises from 0.48 to 0.72 under both of these policies. As in the Dolton and Van der Klaauw (1995b, 1999) papers discussed above, both nonteaching jobs and time out of the labor force are considered as alternatives to teaching. Stinebrickner reports that the wage rises are more likely to reduce the amount of time spent in nonteaching employment, than they are to reduce time spent out of the labor force altogether. Consistent with other research reviewed here, the wage effect on the decision to continue working as a teacher is therefore greater for men than for women.

Although both wage policies in the Stinebrickner (2001a, 2001b) study raise the amount of time spent in teaching by approximately the same amount, they do differ in the extent to which they attract high quality teachers (quality being measured in terms of SAT scores). Not surprisingly, 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. Other papers have also considered this relationship between relative wages, teacher supply and teacher quality. For example,

Ballou and Podgursky (1997) undertake a simulation exercise, using estimates of entry and exit behavior from other studies, to estimate the impact of changing teacher wages. They conclude that a general 20% increase in wages would do little to increase teacher quality, the problem being that higher wages reduce exit from the profession, hence lowering the number of teaching vacancies and so reducing the incentive to invest in teacher training, particularly for those high ability individuals with good opportunities elsewhere. The authors therefore suggest that the wage increase should be implemented together with an attempt to target those of higher ability, or, more cost effectively, making the 20% pay rise conditional on having a certain minimum SAT score, thus removing the need to pay higher wages to all teachers, including those of lower ability. In a similar vein, Hanushek, Kain and Rivkin (1999) use data for the years 1993–1996 from the UTD Texas Schools Project database, which is a matched panel of entire cohorts of pupils and teachers. The authors 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 among pupils of 0.17 and 0.11 standard deviations respectively. These results are not affected when the authors control for turnover, and the effects are larger when probationary teachers are removed from the sample, suggesting that the greatest quality effects arising from wage increases occur through motivating existing teachers, rather than attracting new higher-quality ones.

Summarizing the remaining US papers to have studied the exit decisions of teachers, many have used city or 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 (1989a, 1989b) (Michigan), Murnane and Olsen (1990) (North Carolina), Theobald (1990), Richards and Sheu (1992), Theobald and Gritz (1996) (both Washington) and Greenbaum (2002) (Pennsylvania). These papers all adopt either a dichotomous dependent variable approach based on whether teachers have left their job after a certain amount of time, or undertake a duration analysis of the time spent in teaching. In each case, only individuals who started teaching in a particular year, rather than all teachers in the state, are considered, so as not to confuse wage effects with seniority effects. A problem with using administrative data of this type is that if individuals move states they automatically fall out of the data set, whether or not they have continued as a teacher. The results should therefore be seen as the factors affecting the length of the first job in teaching, rather than the length of time spent in the teaching profession as a whole. The results across all of the studies named above 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 larger for men than for women. There is also some evidence [for example, in the Murnane and Olsen (1990) study] that the influence of teacher earnings declined over time during the 1970s, which is consistent with the UK evidence of Dolton and Mavromaras (1994). Finally the US studies do not consider relative earnings or alternative earnings in the same detail as the UK studies outlined above, with none estimating wage equations to obtain estimates of wages that

could be earned in nonteaching jobs, although most include proxies for outside alternatives, such as qualifications held by teachers, or average district-level wages. The results generally show that teachers with higher level qualifications, or who live in areas with higher average nonteaching wages, and more likely to leave their teaching jobs.

Another aspect of teacher supply relates to the mobility of teachers between different locations. Hanushek, Kain and Rivkin (1999), in the study cited above, assess the role that salary schedules played in the composition of teachers within a district and how pay affected mobility and specifically transitions both between and within Texas public schools. Their evidence suggests that student characteristics play an important role in these decisions and that there is only weaker evidence of the importance of salaries affecting transitions. The typical Texas teacher places a high weight on high achieving nonminority students and such factors act as clear compensating differentials in the decisions to move to another location or exit teaching all together.

An important element to teacher supply are those who return to teacher after a break. Murnane (1996) suggests that in the USA only one in four teachers return to teaching after a career interruption. The decision to re-enter teaching would also appear to be influenced by pecuniary factors. Beaudin (1993) finds those teachers least likely to return are those with better paying employment outside schools.

Econometric evidence from other countries aside from the USA and the UK is limited. Wolter and Denzler (2003) use data on university graduates in Switzerland over the period from 1981–1999 to assess the wage elasticity of teacher supply. They find that teacher supply is responsive to wage levels. However their results indicate that this relationship is not so strong in their data as that reported in other countries. It is possible that part of the explanation for their finding is that teachers are paid relatively well in Switzerland compared to other workers.

4.4. School differences and conditions of work

A most important set of factors which may condition individual labor supply decisions relate to working conditions in schools. In addition the labor market faced by teachers working in some subjects or in certain schools may be radically different from those faced by others. Teaching is quite a different job if you face a large class of 16 year old inner city pupils from deprived homes who simply do not want to be there – than if you face a small class of middle class 5 year olds for whom school is fun. More specifically, variations in working conditions may involve: class size, teaching load, the extent of teaching outside one's area of expertise, the composition and background of the pupils to be taught, the fabric of the buildings and equipment one has to work with, the nature of one's colleagues, the extent of administrative support from local or federal agencies, the degree of classroom assistance by pupils or trained support staff, the opportunities for training and advancement of skills, the flexibility of working practices and many other factors. The issue of the relationship between teacher shortage and class size and teaching loads is of crucial importance to policy makers trying to solve the problems of teacher supply. If there is evidence that teachers are more likely to quit when class size

is higher and other conditions are more adverse then this poses logical questions for policy associated with spending budgets on more teachers – possibly instead of raising the salaries of existing teachers.

There has been relatively little research devoted to the relationship between working conditions and the supply of teachers. Mont and Rees (1996) examine the effect of class load and other factors on teacher turnover. Specifically they examine the role of factors like the number of classes taught, class size and whether a teacher is teaching in the subject area of certification. They suggest that increasing class size, and the greater the number of classes taught, and the higher the percentage of time a teacher has to teach outside their specialist area do have an impact by increasing teacher turnover. They also find that the school district characteristics also play a role in this turnover. Again this research was conducted using data from the New York State Department over the years 1979–1989.

Other studies have also found a role for working conditions effects. Stinebrickner (1999a) finds that the pupil teacher ratio is an important determinant of teacher turnover. However he also finds that the ability level of students is less significant in determining a teacher's view of the school. Likewise Hanushek, Kain and Rivkin (1999) find that the characteristics of the study body are important in why teachers may switch locations. Van den Berghe (2000), using data from Belgium, finds that increasing workload, part time work and centralized decision making increase the leaving hazard but that if the individual works in several schools this reduces the hazard. One of the main conclusions of his study is that nonmonetary working conditions, namely access to teaching jobs with permanent contracts is a more important determinant of supply than salary levels.

There are few studies of the effects of organizational conditions in schools and teacher turnover. Ingersoll (2001a, 2001b) investigates this relationship using data from the Schools and Staffing Survey from the US Department of Education. His results indicate that low salaries, inadequate support from administrative authorities, the presence of student discipline problems and the remoteness of teaching staff from decision making all contribute to higher teacher turnover – even if teacher and other school characteristics are controlled for. The wider issue of the extent to which making teachers accountable but also giving them more control over their working environment has not really been examined in the literature. Indeed will know little about whether there is any relationship between teachers becoming more professional and their decisions relating to their labor supply and turnover.

There is a further literature, which is small but growing, on the relationship between teacher mobility and the social class and ethnic makeup of the school. Greenberg and McCall (1974) in an empirical investigation of San Diego schools finds that new teachers tend to be placed in low SES schools and those teachers who move tend to move to higher SES schools having teachers with greater experience and higher educational attainment. The authors suggest that teacher upward mobility and the fact that higher SES schools have better qualified teachers are both outcomes of the process whereby better qualified teachers gravitate to the more privileged schools. Antos and Rosen (1975) using the 1965 Equality of Educational Opportunity Survey found that an additional

$300 per year (in 1965 prices) would be necessary to induce the average white teacher to teach in a predominantly black school. Undoubtedly there is evidence of teacher supply and mobility decisions being affected by the kind of children in the school. Such factors are important in an explanation of the schools that find it hard to recruit teachers but the consequences for the persistence of inequality of opportunity are potentially massive.

4.5. Subject specialism differences

Another important difference in the teacher supply position relates to the different conditions which exist in the market for school teachers of different subject specialisms. Rumberger (1987) examines the impact of salary differences on teacher shortage for Mathematics and science teachers in the USA. He uses data on a sample of medium and large schools districts in metropolitan areas. Using the salaries of engineers to proxy for wage prospects in alternative occupations outside teaching for science and maths graduates he finds that larger salary differentials between alternative occupations and teaching do induce bigger teacher shortages. Murnane, Singer, Willet (1989) also finds (using his sample of North Carolina teachers from the 1970s) that teachers of chemistry and physics tend to leave teaching sooner than teachers so of other subject specialties. Moreover, they are much less likely to return to teaching once they had left.

Stinebrickner (1998a, 1998b) finds that teachers with a science degree are significantly more likely to leave the profession. Beaudin (1993) finds that teachers most likely to return are those with subject specialties that provide only limited opportunities for alternative employment outside of schools. Such findings are repeated in a number of other studies and suggest that decisions to enter or return to teaching are related to opportunity costs. Clearly those individuals with good outside options because of their skills and qualifications are more likely to be attracted into another profession.

Guthrie and Zusman (1982) discuss the serious shortage of maths and science teachers in the US in the early 1980s. They describe the cause of the problem and suggest a variety of policies to deal with it. Not surprisingly they suggest that relative salaries in teaching compared with other science career alternatives are at the root of the problem. They suggest that more differential pay, more in service staff development and more industry and school cooperation may alleviate the problem.

One solution to the shortage of teachers in the mathematics and science field is to ask teachers of other subjects to teach these subjects. This is an increasingly important phenomena in many countries, including the UK. The issue of the extent of "out of field teaching", i.e. teaching outside one's are area of expertise, is a topic which has been given detailed consideration by Ingersoll (1997, 2000, 2001a, 2001b, 2001c, 2002) for selected areas of the US but has been virtually ignored in other countries. Ingersoll has good reason to suggest that this out of field teaching is commonplace and hides the true extent of teacher shortage.

4.6. Career structure considerations

There is scattered evidence that the career structure in teaching actually affects teacher supply. Issues relating to, if and when, a teacher chooses to move to another school, or into a different kind of job, may relate to the structure of teaching as a career. Specifically, the possibility of moving up the occupational hierarchy and getting promoted to a headteacher or not could be relevant to whether someone chooses to leave the profession early. The actual profile of the age at which an individual teacher chooses to leave the job, and return or not, may well be related to career concerns. Likewise the possibility that a teacher may choose an "optimal time to quit teaching to enter a related field" – like educational administration – may also be related to their age, promotion ladders, and their inability to get advancement in their own school or school district. Alternatively, they could choose to leave teaching as a result of the cumulative occupational stress of successive years at the "chalkface". This evidence is contained in the detailed findings of many different studies – we highlight only some of the more important contributions.

In considering the possible career path for teachers one logical possibility is that teachers may enter educational administration. Brewer (1996) examines this possibility by considering the responsiveness of teachers to opportunities in school administration. Using a sample of newly hired teachers in New York from 1978 to 1988 he finds that male teachers are sensitive to expected administrative salaries. The argument is that teachers often move to fill up the jobs as administrators. Higher district administrator's wages decrease the probability that a teacher will leave the district. Specifically a 10% increase in district administrator salaries reduces quit probability by 0.3%. Dividing male new hires into new entrants and re-hires, effects of own salary and administrators' salary are significant only for new entrants. In addition he finds that if administrative salaries in surrounding districts rise then teachers are more likely to leave their own district. These effects are significant only for males which indicates that female careers in teaching are less likely to consider the administrative route – possibly because such jobs are less compatible with family responsibilities.

Boyd et al. (2002a, 2002b) describe the "career paths" of teachers using administrative individual teacher data from New York State over the last 20 years. The data show that: there is a substantial turnover in teaching in the first years; that students from more selective colleges tend to quit earlier, as do those whose initial job is in an urban area. They find that the age of entry into teaching has been rising. They also find that the proportion of teachers who have failed a Teacher Certification exam have been rising, as has the proportion with Master's degrees. This suggests a wider dispersion in the quality of teacher provision.

Using the same data set Boyd et al. (2002b) examine teacher preferences over their job location. They find that teachers exercise a strong preference to teach close to where they grew up. They suggest that if the location of a job is not considered in modeling individual supply decisions then this may results in an econometric misspecification.

The responsiveness of teacher supply is related to the age of the teacher or their years of experience. There is good evidence that teacher attrition is higher at the beginning of the career and at the end than in the middle. Grissmer and Kirby (1997) found that younger teacher tend to have higher attrition rates. The hazard for leaving teaching rises during the mid-career and then declines with professional experience. Stinebrickner (1999b) also finds this pattern. He suggests that the early years of experience are an important determinant of whether a person stays in the job. He suggests that the hazard rises in the first four years in the job but declines thereafter. These results would suggest that policies to increase retention rates of teachers would be best focused on young teachers and making their conditions of work more acceptable. However this conclusion should be tempered with the fact that much of this age/experience pattern of attrition will be induced by women leaving teaching to have family career breaks. It seems clear that the real problem for policy makers is the men who quit teaching early in their career as they are much less likely to return to the profession.

One aspect of the teacher career choice which is relatively under-researched is the role that expectations of school pupils and students of teaching as a possible future career for themselves play in the formation of subsequent occupational choices. Why is it that the sons and daughters of doctors often want to be doctors but that the sons and daughters of teachers seldom want to follow in the footsteps of their parents? Kyriacou and Coulthard (2000) examine this subject using data from undergraduates views on teaching as a career in the UK. Their work suggests that students have a poor impression of teaching as a potential career due to salary prospects and also to the stressful image of the job.

In a related paper Chevalier, Dolton and McIntosh (2001), consider reported job satisfaction with a number of aspects of working life, using data from the UK 1985 and 1990 Graduate Cohort Data Sets. The results suggest that teachers are less satisfied than other graduates concerning key aspects of their jobs, such as pay and hours worked. However this work does show that teachers are more content with other aspects of their job than those graduates who enter alternative careers. Specifically they are more content with the match of their qualifications with the nature of their work and also their sense of job security.

In their investigation of teacher mobility Theobald and Gritz (1996) examine the teacher decision to teach in the same school district and considers the role of inter-district mobility. They find that expenditure and resources at the district level can impact on the length of time a teacher stays in the profession. Shen (1997) using data from the 1990–1991 US Schools and Staffing Survey examines the teachers who stay in the same school, move to another school voluntarily and those who left teaching of their own accord. The author finds that stayers are statistically distinct from the movers and the leavers. Osei Bempah et al. (1994) using data from a beginning teacher survey in Missouri estimate a model of migrant and nonmigrant teachers. They find that the migration decision is most strongly influenced by home ownership and leadership style of the school administration.

4.7. Female career patterns

The role that gender considerations play in the supply of teachers cannot be underestimated. From the OECD data on different countries we know that around 62% of teachers are women and that in some countries the fraction is as high as 94%. Not only do women choose teaching as a career in their initial occupational choice they also return to the career if they leave it. Beaudin (1993) finds that females return to teaching in higher proportions than males. Those who interrupt at a younger age and with higher qualifications are less likely to return. This means that the teacher labor market is unlike other in terms of its reliance on female labor. As a result – more than in nearly any other professional labor market – we need to be aware of the issues of female labor force participation and the wishes of women to have career interruptions or work part time.

Many of the econometric studies report findings separately for men and women and as a result explicitly show how the labor supply decision of women is particularly important in the context of the teacher labor market. Dolton and Van der Klaauw (1999) make a distinction between exiting teaching for family reasons and exiting to another job. This distinction is a particularly important aspect of female labor supply. They also find that women from higher social classes and privileged schools are more likely to leave the workforce; those with education degrees are less likely to quit teaching for a nonteaching job and those with postgraduate qualifications are more likely to quit teaching and those who entered the profession reluctantly are more likely to exit involuntarily or for family reasons.

An important aspect of female teacher labor supply has been the changing opportunity set in terms of alternative careers for women over time. Corcoran, Evans and Schwab (2002) examine how the propensity for educated women to enter teaching has changed over time in the US over the period 1957–1992. They find that although the quality of the average new female teacher has fallen slightly over this period, the likelihood that a women from the top of her high school class will enter teaching has fallen from 20% in 1964 to under 4% in 1992. A major part of the explanation of this change has been that other employment opportunities for women have changed remarkably over this time period.

One particularly important dimension of teaching as a career for women is the flexibility of working time. Flyer and Rosen (1997) using the NLSY from 1979–1991 examine the transitions of women college graduates between the home and the market sector. They suggest that teaching provides for more flexible allocation of time between market and home production. They investigate whether teaching as a career for women provides a more flexible alternative which is compatible with home production. They suggest that teaching does provide a more flexible market to facilitate this intermittent pattern of participation in work combined with periods of household production. Such interruptions are shown to be less costly for women teachers than women graduates who have alternative careers in that that women teachers do not suffer such big pay penalties for taking time out of the labor market. Women college graduates who take jobs outside teaching face an average 9% pay penalty for each year spent out of the labor

market. Flyer and Rosen suggest that the flexibly afforded by a teaching career offers an important attraction to the profession for women.

Personal circumstances relating to family obligations play a very important role in the decision to become and remain in teaching. Dolton and Makepeace (1993) show that for women the decision to become a teacher and participate in the labor market need to be considered simultaneously as these decisions are endogenously related. This is true in the sense that unobserved factors, which make a woman more likely to select a career outside teaching, make them less likely to participate in the labor market and vice versa. This generates a positive correlation in the teaching occupational choice decision and the decision to work.

For many women – up to 60% in the US [see Stinebrickner (1999b)] – leaving teaching can mean leaving the workforce all together. Stinebrickner (1999a, 2001a, 2001b) finds that changes in marital status and the birth of a child play a key role in teacher supply. Clearly for a women the decision to continue in teaching after the birth of a child have to be assessed very carefully in relation to the extra cost associated with child care. Since remaining in full time teaching after the birth of a child will require day care provision then the birth of a child lowers the effective wage on offer and this may effect whether a women decides to continue in her job. Stinebrickner suggest that child-care subsidies may represent an efficient way to increase teacher supply relative to increasing teacher salaries. Further work by Csellack (2002) using a dynamic occupational choice model suggests that the marital and fertility decisions need to be treated endogenously to the modeling of teacher career choice and specifically whether a person actually works in teaching in any specific year.

Dolton and Mavromaras (1994), use data from both the UK graduate cohort surveys of 1970 and the 1980 to provide comparisons over time for men and women. The results show that the influence of relative earnings on the decision to remain in teaching declines between these two dates. Specifically, the authors estimate that a 10% rise in relative teacher earnings would increase the probability of currently being a teacher by 9.67% for 1970 men, but only by 1.37% for 1980 men, and by 3.03% for 1970 women, but only 2.38% for 1980 women. The authors also decompose the cause of the fall in the likelihood of becoming a teacher into changes in the characteristics of the individuals themselves, and changes in the characteristics of the job market that they face, with the latter dominating. The average man is 5% more likely to become a teacher in 1970 than in 1980, with this fall being due entirely to deteriorating market conditions for teachers. The characteristics of 1980 men are actually more favorable to becoming a teacher than those of 1970 men. Similarly, women are 8% more likely to teach in 1970 than in 1980, almost all of which is due to market conditions, the favorability of individual characteristics having barely changed.

4.8. Other aspects of teacher supply

There are many other factors which impact on teacher supply, some of which have been rarely examined in the literature. A particularly important feature of the teacher

labor market is the presence, in many countries, of quite strong trade unions. Much of the literature on teacher unions has sought to examine the relationship between unions and pupil outcomes or school choice [e.g. Hoxby (2000), Eberts (1987)]. Such studies have little to say about the teacher supply consequences of the presence of trade unions or their activities. There are a few studies however that do address the issue (albeit briefly) of the relationship between teacher trade unions and aspects of teacher wages and teacher supply [Currie (1991), Baugh and Stone (1982) and Easton (1988)].

Historically, in the UK and the USA, teaching has been a heavily unionized profession. This is partly due to the nature of the union in this occupation is that it acts as a professional club and also provides members with a degree of insurance against allegations of negligence or abuse, or accident when in charge of children. Nevertheless, there are clear supply and wage consequences of the heavy presence of unions in teaching. Eberts (1987) finds union negotiated contract provisions and class size limitation provisions reduce the probability of teacher separation in unionized districts in New York State in the 1970s. Rees (1991) examines the relationship between teacher quits and the strength of grievance procedure. Using data from New York State public teachers in the mid 1970s he finds that teachers with the strongest types of grievance procedures in their contracts had a lower probability of quitting that those working under weaker grievance procedures. The author suggests that this provides evidence that unionization can reduce quits through a voice effect.

5. Future research

The overwhelming conclusion of much of the empirical econometric research on the supply of teachers is that problems of teacher shortage could be alleviated with higher relative teacher salaries. If relative teacher salaries were higher then the problems of teacher recruitment, retention and duration would be alleviated. This is a relatively straightforward prediction given any simple economic model of occupational choice which is based on the choice of career based on the criteria of the maximization of expected future lifetime earnings. There are many important assumptions in such a model which were discussed in Section 3. Here we recap the most limiting of these assumptions as they provide directions for future research. Explicitly the model assumes that: the only element to the decision criteria is expected future lifetime earnings and that nonpecuniary factors do not matter, secondly that the agents have perfect foresight about the path of these expected future lifetime earnings which are naively assumed to grow at a constant rate and thirdly that there are no radical changes to these initial conditions.

There are further technical econometric problems in the modeling of teacher supply in that there are many other decisions which the individual takes simultaneously with deciding to become (or remain) a teacher. Firstly the decision to participate in the labor market and secondly how much labor to supply are not exogenous of the decision of becoming a teacher. Also, for a woman, the decision to get married and have children may not be independent of her decision to study education and become a teacher. We

have seen that there is already some empirical evidence that occupational choice, participation decisions, and marital and fertility decisions are all inter-related for women teachers. The problem with all these interrelated decisions are that they are complex to model simultaneously and so far there has only been modest progress on models which incorporate these complexities. The early dynamic programming papers on teacher supply have attempted to unravel the main elements of these decisions. These models of teacher supply represent one promising avenue of future investigation with the advent of larger, more comprehensive, data – but much work remains to be done. In this context it is possible that more use could be made of merged exogenous data. Likewise attempts to model these decisions using static cross-section data have fallen foul of the problem of the lack of appropriate instrumental variables or exclusion restrictions which could be used to identify the different elements to these distinct but related decisions.

Further econometric difficulties are apparent whenever one wishes to evaluate the nature of any policy change in the field of teacher supply. For example, it is unclear exactly how to model the effect of any change in teacher's wages on the overall supply of teachers. The complexity of this process has been outlined in this chapter but there are many opportunities for good empirical work which could use actual policy regime shifts to identify the effect of policy changes. Techniques of quasi or natural experiments and regression discontinuity design could be profitably used in this area. Features like changing administrative regimes for the hiring or remuneration of teachers over time could be used to identify the effects of relative wage effects on teacher supply.

One of the important assumptions in almost all of the models of teacher supply which have been investigated is that both the wage in teaching and the wage in nonteaching will grow at a constant rate. Not only is this assumption very naive but potentially wrong. By using various data sets it could prove possible to not only retrieve teacher wages, but also that of nonteachers, over the whole lifecycle. [See Dolton and Chung (2004) for a first step in this direction.] This would mean that rather than assuming that earnings grew at a constant rate in the alternative careers – real data could be used to more accurately reflect the true empirical position. However it is clear that there needs to be more work on the issues of modeling educational investment decisions under uncertainty.

Another area for fruitful research would be in the role that nonpecuniary factors play in the decision to become (or remain) a teacher. There is only a very limited literature which recognizes that such factors could be important in the decision to enter or stay in the teaching profession. Examination of the pattern of life cycle earnings for men in the USA and the UK in teaching and nonteaching alternatives shows that if earnings were the only criteria used to decide a career then no men would become teachers in these countries. Hence other factors must play an important role in this decision. This is a topic worthy of careful research, not least because one of the perennial problems of teacher supply is how to recruit the highest ability individuals into the career. If it was clearer as to exactly what the nonpecuniary benefits of teaching were, we could target individuals who most highly rated these attributes of a job. In addition, good research in this area might also reveal what were the most important negative aspects of a teaching career in terms of working conditions and appropriate measures may be

devised to ameliorate these negative aspects of the job. More specifically there is scope for detailed empirical work on the relationship between job-satisfaction, nonpecuniary work conditions and the rate of turnover of teachers. New data sets are being collected which emphasize the role of these factors in occupational choice and satisfaction. They could be profitably used to shed light on why graduates enter the job of teaching and why they stay in the occupation when their remuneration could be much higher in an alternative occupation.

There are many possible directions for future empirical econometric research into the labor market for teachers. Perhaps the most promising lines for future research have been opened up by important new data sources. Particularly exciting are the prospects of being able to use detailed administrative data on teachers over their working careers. Specifically, many countries now have census like databases of teachers. In the UK the Database of Teacher Records (DTR) has detailed information on all 1.9 million people who had become teachers since 1961. Likewise some US states now have good administrative data on teachers [e.g. Boyd et al. (2002a, 2002b)]. The data allows us to track who is in and who is out of the teacher labor force at any given time – knowing precisely when they entered the teacher profession, when they left and when they returned. One advantage of administrative data over survey data is that there is no problem with nonresponse and the bias that this may cause. Another advantage of administrative data is that it is possible to conduct realistic analysis of important subgroups which are difficult to study with survey data due to lack of sample size. Specifically with administrative data it is now possible to further study the supply of teachers in key subjects and particular geographical locations as the literature is relatively thin in this area.

There are many other areas in which our knowledge about teacher supply is scant. Although teacher shortage is widespread we know from empirical evidence that many young people still choose to be teachers despite the low pay. Clearly nonpecuniary factors matter in occupational choice but we know relatively little about this part of the process and how it operates. We also know relatively little about the role of expected future lifetime earnings in the decision process and how people trade this off against a job which is rewarding. We also know little about young people's perceptions of teaching as a career or their real relative perceptions of earnings in teaching. In some countries there are a sizable number of teachers who enter the profession in mid-career after working in the private sector for some time. One interesting earlier exception is Pavalko (1970). We need to know more about what motivates these individuals to make these choices and if they are more effective teachers due to their outside perspective on the real world.

Further opportunities to study the problems of teacher supply may be possible by the collection of reliable data on teacher vacancies. Hitherto, this data has been patchy as not all vacancies are recorded centrally. But the signs are that good data on teacher vacancies is now being recorded nationally via comprehensive data collection and website accessibility to these records. It is not impossible that fruitful analysis of this data by subject and geographical location over time might provide further insights into the problem of teacher supply.

A further natural area for research work is to compare the position on the state of teachers across different countries. There is now a large amount of data in different countries – some administrative and some survey data which can be used to study how different the problems of teacher supply are in different countries. Such data also raise the possibility of genuine comparative work across countries. The natural direction for this work is to consider studying the aggregate labor market for teachers in a panel dataset of all countries over time. Section 2.4 of this chapter has made a first step in the analysis of inter country teacher salary variation but it is possible, with improved data from the OECD and other sources, that other aspects of the international market for teachers and its variation across countries and over time might be examined in the future.

Another further empirical challenge is the opportunity of modeling teacher supply decisions in a time series context. Longer runs of data collected nationally are becoming available in order to model the role of changing relative wages and unemployment prospects on teacher supply at the aggregate level. Although sometimes the problems with such data are an insufficient number of years worth of data there is also the possibility of using panel data by considering the supply of teachers in different subject areas in different geographical locations over different time periods. A further challenge in this area is the possible integration of the times series data with individual cross section data from different cohorts. Such data could be used to estimate a dynamic programming model of individual choices allowing for the changing relative wages and unemployment conditions faced by different cohorts at different points in time.

A perennial problem of teacher supply is that it is not simply about recruiting a specific number of teachers. The real challenge of teacher supply is to get high-quality individuals into teaching who have the most appropriate personalities to be good teachers. To some extent this does not necessarily mean the most able individuals – but often those with the capacities to be good teachers. What makes a good teacher is not something which can be easily measured.

Teacher quality is extremely difficult to observe and there is a principal-agent type relationship between individual teachers and their administrative authorities. [See Dixit (2000).] That is to say – it is very difficult to observe, or accurately measure, the amount of effort exerted or output produced by any individual teacher. Naturally governments and state agencies should try to maximize the effective use of the tax-payers money spent on education – this means that there should be appropriate attempts to monitor spending on teachers. The problem with this is that we do not fully understand: how to measure teacher quality, how teacher quality affects pupil performance, how to measure effective teacher input or effort. [See Figlio (1997), Odden and Kelley (1997), Ehrenberg and Brewer (1994, 1995), Loeb and Page (2000) and Nickell and Quintini (2002).] Under these circumstances it is tempting for government to try to introduce various incentive mechanisms and even performance related pay for teachers. Such pay schemes have created a vibrant debate over the value of teachers but there is insufficient understanding of the effects that such schemes could have on incentives and outputs or recruitment and retention. The current state of knowledge is overviewed in Adnett

(1999) and Dolton, McIntosh and Chevalier (2003) but this is a very fruitful are for future research.

The consequences of the teacher supply problem are inequitably felt across different socioeconomic groups in any society. There is some evidence that the pupils from the poorest homes are the ones who have problems in getting teachers to teach them in the sense that it is the schools in the least well-off areas that have the biggest problems with recruitment, retention, turnover and even absence of teachers.[12] These factors must act as a force which continues to generate educational and hence later income inequality [Darling-Hammond and Berry (1999) and Darling-Hammond (2000)]. There has been little systematic research into the inequality consequences of teacher supply and this topic should be on the agenda for future research.

6. Conclusion

It is clear in most countries that there are teacher supply problems. There would appear to be a lot of evidence from many different states in the USA and from other countries around the world that there are persistent episodic shortages of teachers. This manifests itself in terms of not enough recruits entering the profession and too many leaving it prematurely. However, it is also clear that there is not a universal shortage of all categories of teacher. Specifically, teachers are in short supply in difficult schools in areas with inner city urban problems and in subjects which have a high opportunity wages for those with specific technical skills. The problems seem to be worst in the scientific and mathematical subjects. Hence the real challenge of teacher supply is to get teachers into teaching the subjects and areas that are not appealing. The straightforward economic answer is to consider higher pay for those shortage categories. It is unclear whether teacher trade unions would be prepared to countenance these proposals but good economic and econometric research in these areas could calibrate the problem and provide some simulations as to the effective salary scale differences which may be required in these key areas to solve the problem. There is a considerable body of time series and cohort evidence that the shortage problems could be alleviated with higher relative salaries for teachers. What is less clear are the long term consequences of having children taught by temporary, or low quality teachers. High teacher turnover probably has a price in terms of the quality of educational instruction that children receive – but there is little evidence on this issue.

The perennial challenge for governments and education administrators is to establish a high-quality teacher labor force which is hard working and effective. Such problems could easily be solved by paying teachers higher wages. The problem of course is that governments are reluctant to throw more money at such problems and that even if they

[12] In the USA 15% of teachers are unlicensed in some inner cities – indeed in California 1 in 5 kids are taught by underqualified teachers.

did it, is not clear what the outcome of increased expenditure is – precisely. Hence more research on the relationship between educational resource inputs, teacher quality and outcomes must inevitably have important lessons for the importance of teacher supply. For example, if we knew categorically that the size of teacher pupil ratios had no effect on pupil outcomes then we could simply solve teacher shortage problems by having larger classes. In addition, we do not know in much detail, the effect of teacher working conditions on their relative effectiveness. To what extent do we alienate teachers from their jobs if we ask them to keep more detailed pupil records and does this induce significant numbers to leave the profession? There are many unanswered questions relating to teacher supply which deserve the attention of research in the future.

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