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ABSTRACT

In light of the current increase in elementary and secondary school attendance coupled with a simultaneous decrease in college-age population between now and the end of the decade, this study assesses (1) the role of economic factors in determining the number of teachers certified and (2) the responsiveness of teachers in the "reserve pool" to current teacher salaries. Since similar demographic trends existed in the past, time series data from 1950 to 1979 are examined to develop an economic model of the decision to receive teacher certification and the ensuing decision to participate in teaching once certified. Structural parameters of this model are estimated; the results indicate an important role for economic factors in the public school teachers market. The point estimate of the wage elasticity of the supply of teachers already trained is .72 for secondary school teachers and .81 for elementary school teachers, so that a 20 percent increase in wages would induce a 14.4 percent increase in the supply of secondary school teachers. The short-run elasticity of teacher certification with respect to a permanent change in the expected wage is 1.36 and 1.80 for secondary and elementary schools respectively, allowing for changes in the college-going behavior of students in response to the expected wage for teachers. These results suggest a substantial wage response in the public school teachers market. Two appendixes supply data sources and the calculation of the trained teacher series. Extensive references are included. (Author/TE)

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Gary A. Zarkin

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Abstract

Elementary and secondary school enrollment in public schools is expected to increase from now through the end of the decade. At the same time, the college-age population is expected to decrease steadily. Do economic factors play a role in determining the amount of teacher certification? How responsive are the teachers in the "reserve pool" to the current wage in teaching?

The education sector faced similar questions in the 1950s and 1960s. This study uses time series data from 1950-1979 in order to learn from that previous experience. An economic model is developed of the decision to receive teacher certification and the ensuing decision to participate in teaching once certification has been received. Structural parameters of this model are estimated and the results indicate an important role for economic factors in the public school teachers market.

The point estimate of the wage elasticity of the supply of teachers who are already trained is .72 for secondary school teachers and .81 for elementary school teachers. This means, for example, that a 20% increase in wages would induce a 14.4% increase in the supply of secondary school teachers. The point estimate of the short-run elasticity of teacher certification with respect to a permanent change in the expected wage is 1.36 and 1.80 for secondary and elementary schools, respectively, where changes in the college-going behavior of students are allowed in response to the expected wage in teaching. These results suggest a substantial wage response in the public school teachers market and demonstrate the importance of economic factors in the supply of public school teachers.

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I. INTRODUCTION

In studies of occupations requiring an investment in training, it is necessary to deal with expectations of the future in some way. The reason for this is that training entails substantial costs in terms of direct and indirect expenses such as tuition and foregone opportunities, while the returns from this training accrue in the future. In this regard, occupational choice has a capital-like feature much like an investment in a specialized machine. However, most previous work in this field does not satisfactorily treat the potentially important effects of future market conditions on occupational decisions. Examples of work which do not adequately treat these effects are, in addition to Freeman's work which is cited below, Boskin [1974], Friedman and Kuznets [1945], Schmidt and Strauss [1975], and Zabalza [1979]. Exceptions include Pashigian [1977], Siow [1984] and Zarkin [1985].

Richard Freeman [1971, 1975a, 1975b, 1976a, 1976b], who has done the most extensive work on occupational choice, usually postulates that new entrants look solely at their expected starting salary when making their occupational decisions, and that changes in starting salary profoundly affect occupational choice. Because of the capital-like element of occupational choice, however, starting salaries may not necessarily be a good guide to the profitability of investments in occupational training. It is quite possible that even though expected starting salaries are competitive with other jobs, the future may be either very bright or very bleak.

This point is particularly important in the market for public education. Since the number of children enrolled in school in the aggregate is essentially deterministic once children are born, future demand conditions (i.e., the number of children enrolled in school) are readily forecastable with current information. Thus, even if expected starting salaries are large relative to their alternatives, future wages can be expected to deteriorate if the number of births declines secularly.

Another aspect of Freeman's work that is important to consider is the postulated forecasting mechanism. Freeman uses the current value of the starting salary in order to generate the forecast of future starting salaries.[1] Since people are myopic with respect to future demand conditions, it is not surprising that we can develop cobweb models in which forecast errors persist for long periods of time.

In contrast, the model proposed in this study specifies that: (i) people look beyond expected starting salaries in their occupational decisions and take into account future forecastable demand conditions, and (ii) people form expectations rationally in the sense of using the actual structure of the model to generate these expectations.

The study developed here also extends the work of Zarkin [1985] in two directions. First, in contrast to all previous time series economic models of occupational choice, the model developed explicitly accounts for the switching between teaching and other occupations once teacher training has been completed. Second, this study recovers the structural parameter estimates of the model rather than just the reduced form estimates of previous work.

In order to set the stage, Figure I depicts the change in enrollment in public schools over the period 1950-1979. The figure demonstrates the dramatic movement in enrollment for both elementary and secondary schools. Elementary school enrollment increased 56 percent from 1950-1970, whereas it decreased 13 percent from 1970 to 1979. Secondary school enrollment rose approximately 300 percent from 1950 to its peak in 1975.

In response to these changes in enrollment, there have been equally

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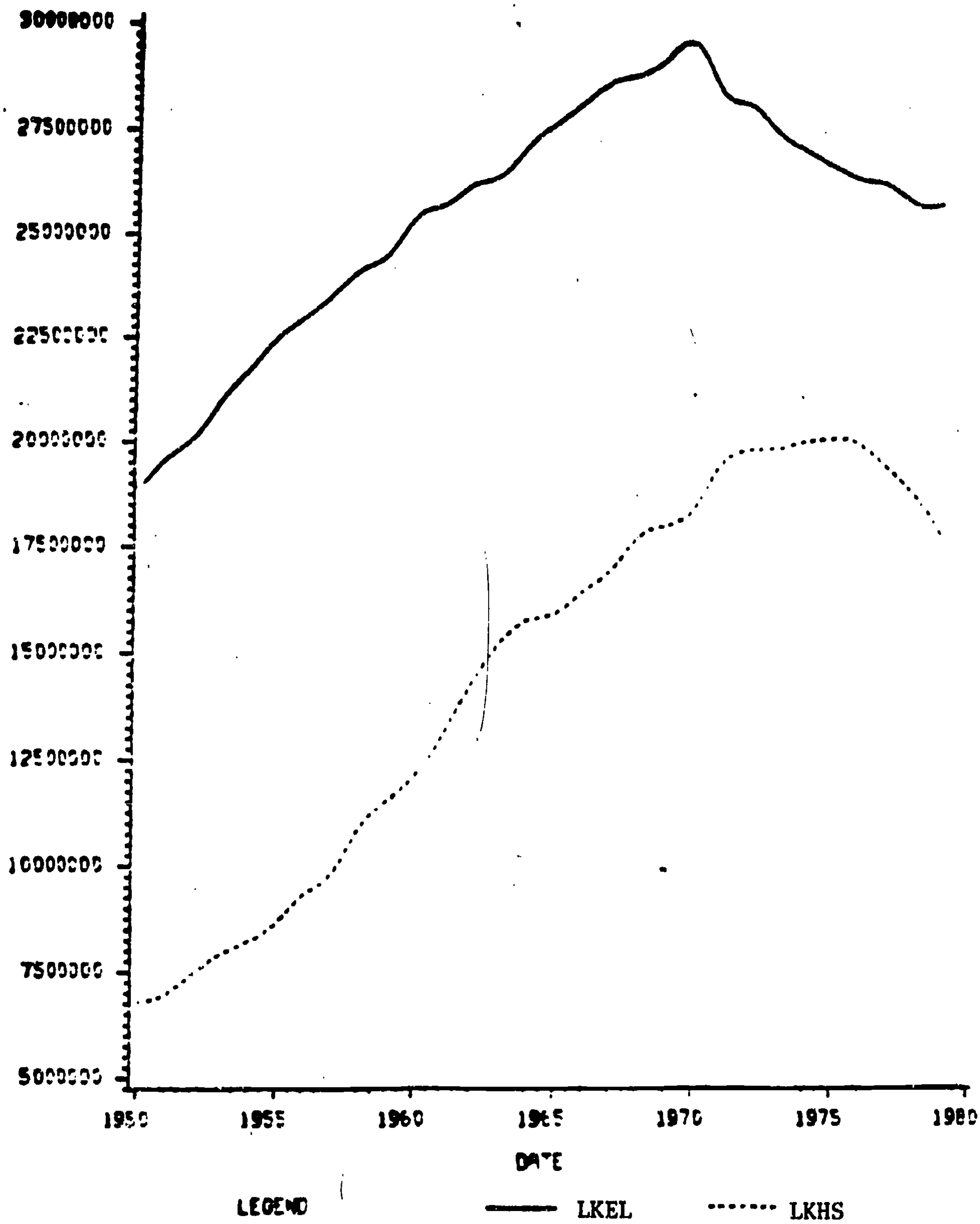

LKEL=ENROLLMENT IN ELEMENTARY SCHOOL
LKHS=ENROLLMENT IN HIGH SCHOOL

Fig. 1.-- Current enrollment

striking changes in the number of college graduates receiving training in elementary or secondary education.[2] Figure II depicts the total number of college graduates completing certification requirements. To put these numbers into perspective, the proportion of elementary school teacher graduates relative to the total number of college graduates fell from a peak of approximately 18 percent in the mid-fifties (a period of relatively few college graduates) to a low of 7 percent in 1979. On the other hand, the proportion of secondary school teacher graduates peaked approximately ten years later at 23 percent of all college graduates and fell to a low point in 1979 of 8 percent.

Two features of these data are important to stress. First, approximately 38 percent of all college students received certification in elementary or secondary education at the peak in the mid-sixties. This testifies to the importance of the public education training sector through much of the post-war period. Therefore, studying the decison to acquire educational certification sheds light on the behavior of a significant proportion of college graduates.

Second, comparing the turning points in Figures I and II suggests that an economic model is of some interest. In particular, notice that the number of people receiving secondary school certification peaks in 1971, four years before the downturn in secondary school enrollment. In contrast, the turning point in the number of people receiving elementary school certification is approximately one year after enrollment decreases. These patterns suggest that movements in future forecastable demand conditions affect the number of people receiving secondary school certification, and that a model that incorporates the importance of economic incentives in the certification and supply decision of teachers will provide a useful perspective.

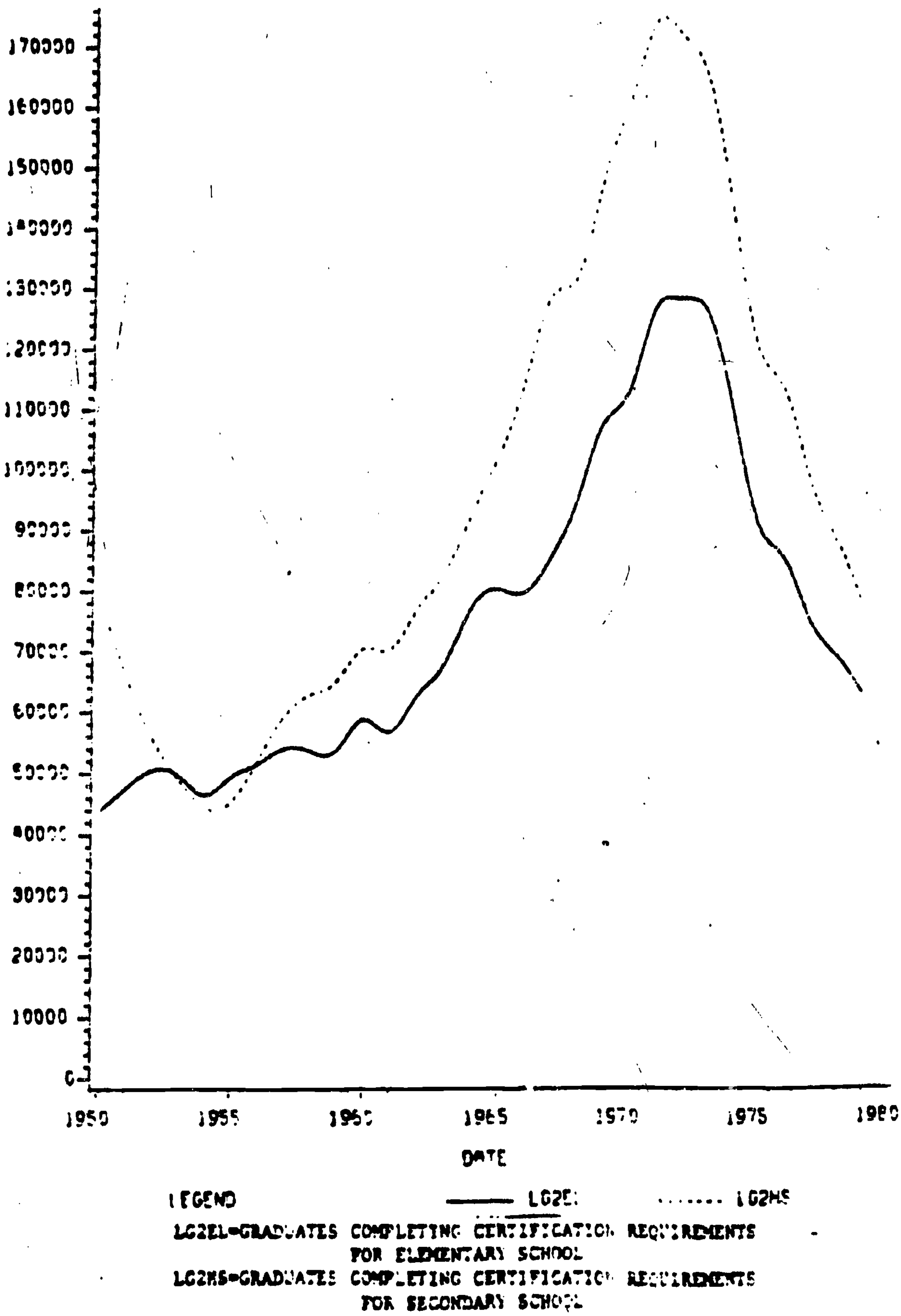

Fig. 2:—Graduates completing certification requirements

The empirical results based on the model developed here bear out the importance of economic incentives in the recruitment of teachers. The point estimate of the wage elasticity of supply of teachers who are already trained is .72 for secondary school teachers and .81 for elementary school teachers. This implies that a 20% increase in wages would induce a 16.2% increase in the supply of people willing to teach elementary school.

The results for the decision to receive certification are more subtle. The point estimate of the short-run elasticity of teacher certification with respect to a permanent change in the expected wage, or alternatively, the elasticity with respect to a transitory increase in the expected wage is 1.36 for secondary school certifications and 1.80 for elementary school certifications. Neither of these estimates, however, hold constant the number of college graduates. The effect of adding college graduates to the secondary school regression is to swamp the explanatory power of teacher wages. It appears that much of the responsiveness of changes in the wage in secondary school teaching arises through changes in the college-going behavior of people receiving teacher certification. This implies that people who receive secondary school teacher certification may not have otherwise graduated from college. This does not appear to be the case, however, for elementary school certifications.

The paper is organized as follows. Section II develops a stock-flow model in which newly-certified teachers are added to the past stock of trained teachers, who in turn "depreciate" over time. Section III discusses the empirical strategy and methodology. Estimates of the model are presented and discussed in Section IV. Section V contains a summary and conclusion.

II. The Model

Suppose that there exists a wage, W_t, which all teachers receive if they choose to teach in period t. People differ, however, in the opportunity wages, W_t^o, that they could receive outside of teaching.[3] Once people receive their teacher training, they decide whether to work as a teacher in a particular period by comparing the current wage in teaching at time t, W_t, to the current wage in the next best alternative. W_t^o. All people whose wage in teaching exceeds their alternative wage will choose to teach in that period. At the margin W_t will just equal W_t^o. If W_t^o is distributed in the population according to the probability density function, $f(W_t^o)$, the number of trained teachers who actually teach in period t is $AT_t = F(W_t)TT_t$. AT_t is the number of trained teachers actually teaching in period t, TT_t is the number of trained teachers in period t, and $F(W_t)$ is the cumulative distribution function evaluated at the point $W_t = W_t^o$. The latter term is the left-hand tail area of the $f(\cdot)$ distribution and it represents the proportion of trained teachers who choose to teach in period t. To a linear approximation, the actual number of teachers is

$$(1) \qquad AT_t^s = \alpha_1 \bar{W}_t^o + \alpha_2 TT_t + \alpha_3 W_t + \epsilon_{1t}$$
$$\alpha_1 < 0,\ 0 < \alpha_2 < 1,\ \alpha_3 > 0$$

where $\bar{W}_t^o$ is the mean of the f distribution and ϵ_{1t} is a random disturbance. According to equation (1), the supply of teachers increases the greater the wage in teaching, W_t, the greater the supply of trained teachers, TT_t, and the lower the mean of the opportunity wage, $\bar{W}_t^o$.

A person acquires teacher training if the expected discounted present value from teaching $\hat{V}^T_t$ exceeds the expected discounted present value from their next best alternative, $\hat{V}^o_t$. $\hat{V}^T_t$ and $\hat{V}^o_t$ are defined as:

$$(2) \quad \hat{V}^T_t = \sum_{i=0}^{N} \beta^i F(\hat{W}_{t+1})\hat{W}_{t+1} + \beta^i [1 - F(\hat{W}_{t+1})]\hat{\bar{W}}^o_{t+1} = F(\hat{W}_t)\hat{W}_t + [1 - F(\hat{W}_t)]\bar{W}^o_t + \beta V^T_{t+1}$$

$$(3) \quad \hat{V}^o_t = \sum_{i=0}^{N} \beta^i \hat{\bar{W}}^*_{t+1}, \qquad 0 < \beta < 1$$

where β is a discount factor, N is the length of life and the carets indicate the expectation formed as of period t - 2. Note that the expected present value from teaching allows for the possibility that people do not always teach once they are trained.[4]

The cost of teacher certification is the training foregone in an alternative occupation which pays W^*_t. This is the wage received in the occupation precluded by the choice of teacher certification. Once a person acquires teacher certification (or any other type of occupational training) his choice of future occupations is restricted to those that require approximately the same amount of formal training.[5] On the other hand, an advantage of receiving teacher certification as opposed to a general liberal arts degree is that the person always has the option of switching into teaching if the wage in teaching exceeds the opportunity wage, W^o_t. This is the wage received in the alternative occupation, conditional on receiving teacher certifiction. In general W_t does not equal W^*_t. In the empirical work below, nursing and engineering capture the occupations precluded by teacher certification and the median wages of male and female professional, technical, and kindred workers represent the alternatives facing those who have received teacher certifications. It is quite consistent with the model that some people who do not desire to work in teaching for their entire lives would still acquire teacher certification.[6]

The marginal person receiving teacher training from a given age cohort is just indifferent between teaching and the next best alternative so that $\hat{V}_t^T = \hat{V}_t^o$. If the density of $\hat{V}_t^o$ is represented by $g(\hat{V}_t^o)$, the expected number of people receiving teacher certification in period t is $\hat{R}_t = \hat{C}_t \cdot G(\hat{V}_t^T)$ where $\hat{C}_t$ is the expected number of college graduates in period t and $G(\cdot)$ is the cumulative distribution function evaluated at $\hat{V}_t^T = \hat{V}_t^o$. As written, this expression ignores the possibility that people who receive teacher certification may not otherwise have graduated from college. In the empirical work below, we allow for this possibility and it appears to be an important issue. The expected number of newly-certified teachers can be approximated by the linear relationship:

$$(4) \qquad \hat{R}_t = \psi_0 \hat{V}_t^T + \psi_1 \hat{\bar{V}}_t^o + \psi_2 \hat{C}_t + \varepsilon_{2t}$$

$$\psi_0 > 0, \ \psi_1 < 0, \ 0 < \psi_2 < 1$$

where $\hat{V}_t^T$ is the equilibrium expected present value from teaching, $\hat{\bar{V}}_t^o$ is the mean of the $\hat{V}_t^o$ distribution and ε_{2t} is a random disturbance. The expected number of newly-certified teachers increases the greater the expected present value from teaching, $\hat{V}_t^T$, the lower the expected mean of the opportunity present value, $\hat{\bar{V}}_t^o$, and the greater the expected number of college graduates, $\hat{C}_t$.

The supply of trained teachers is defined by the following equation:

$$(5) \qquad TT_t = (1 - \lambda)TT_{t-1} + \hat{R}_t + \varepsilon_{3t}$$

$$0 < \lambda < 1$$

where λ is the exogenous depreciation rate (or death rate) from the stock of trained teachers and ε_{3t} is a random disturbance. In order to close the model, suppose that the demand for teachers can be represented by

$$(6) \qquad AT_t^d = \gamma_1 W_t + \gamma_2 K_t + \gamma_3 D_t + \varepsilon_{4t}$$
$$\gamma_1 < 0, \ \gamma_2 > 0, \ \gamma_3 > 0$$

where K_t is the number of children enrolled in public school, D_t is a vector of other exogenous demand shifters and ε_{4t} is a random disturbance. The demand for teachers increases the more children enrolled in school, the lower the wage in teaching, and the greater are other demand shifters.

Equations (1)-(6) define the model. Although I do not pursue it here because it is unnecessary for the task at hand, a solution for the model can be obtained by the method of undetermined coefficients (see Zarkin [1985]). In a nutshell, the solution method solves for the equilibrium path of wages, actual teachers, and new certifications as functions of the exogenous variables.

As noted in Zarkin [1985], various implications arise from such a solution. An increase in the number of expected future children or other forecastable demand conditions tends to increase the current number of newly-certified teachers. In contrast, increasing the expected opportunity present value tends to decrease the supply of newly-certified teachers. The magnitude of the effects of increases in current and future children enrolled in school on the number of actual teachers and on the wage rate depends on, among other things, the supply responsiveness of trained teachers to wage changes. In particular, if the supply of actual teachers is highly responsive to changes in current wages, periods of high demand for teachers will be met largely from the pool of trained teachers, with little change in the wage rate. A policy implication of such a situation is that so-called "teacher shortages" can be eliminated with salary increases.

III. Estimation Strategy and Methodology

One of the major purposes of this study is the estimation of the parameters of the supply curve of teachers once they are trained (equation 1), the demand curve for teachers (equation 6), and the supply curve of newly-certified teachers (equation 4). The market is assumed to clear each period so that $AT_t^D = AT_t^S$ for all t. Because of this, ordinary least squares estimation of equations (1) and (6) will be inconsistent due to the correlation between W_t and the random disturbance in each equation. This can be handled by the use of two stage least squares whereby W_t is essentially replaced by $\hat{W}_t$, which is the predicted wage based on the reduced form equation. The instruments used for the secondary school reduced-form wage regressions (with their counterparts used for the elementary school regressions)[7] are HSEXR, the Federal Office of Education Expenditures per student enrolled in secondary school; LKHS, the number of children enrolled in secondary school; TSLAG, the number of secondary school teachers employed in the previous year; LOPPWMR, the opportunity wage facing already-trained secondary school teachers; and TTHS, the contemporaneous stock of trained teachers.[8] The first three of these variables enter the demand curve only and the latter two shift the supply curve. TTHS is determined by decisions to receive teacher certification two periods before and earlier. As long as any serial correlation in the structural errors is less than two periods, TTHS will be pre-determined with respect to contemporaneous shocks to demand or supply and it is a valid instrument. Evidence presented below indicates that such a condition holds. The expenditures included in HSEXR are not day-to-day expenses (the bulk of these expenses are paid by state and local governments), but rather they reflect special federal programs impinging on the teacher-student ratio. This series is meant to capture exogenous policy changes which affect the quality of education.

In order to estimate an equation (4) that is linear in the dependent variables we must obtain a linear form of V_t^T.[9] Notice in equation (2) that W_t and W_t^o enter multiplicatively. A linear approximation of equation (2) is:

$$\hat{V}_t^T = \phi_1 \hat{W}_t + \phi_2 \hat{\bar{W}}_t^o + \beta \hat{V}_{t+1}^T. \qquad (7)$$
$$\phi_1 > 0, \ \phi_2 \gtrless 0$$

This approximation assumes that the mean wage in teaching (over time) is no less than the mean wage in the feasible (i.e., conditional on receiving teacher certification) alternative occupation. It is no surprise that an increase in the expected wages at time t increases the expected present value from teaching. The ambiguity of the sign of $\hat{\bar{W}}_t^o$ arises from two offsetting effects. An increase in $\hat{\bar{W}}_t^o$ increases the expected salary that can be earned, once trained, holding constant the probability of teaching. However, it also decreases the probability of teaching, which pays more on average than does the alternative occupation.

Substituting (7) into (4) and recalling that the carets refer to the expectation as of period t - 2 we obtain:

$$\hat{R}_t = \psi_0 \phi_1 \hat{W}_t + \psi_0 \phi_2 \hat{\bar{W}}_t^o + \psi_0 \beta \hat{V}_{t+1}^T + \psi_1 \hat{\bar{V}}_t^o + \psi_2 \hat{C}_t. \qquad (8)$$

Whereas actual values of W_t, $\bar{W}_t^o$ and C_t are observed in period t, V_{t+1}^T and $\bar{V}_t^o$ are not observed since they reflect agents' expectations over an N-period horizon. However, we can exploit the fact that an equation such as (8) holds each period. From the viewpoint of agents in t - 2, their best forecast for the number of newly-certified teachers in t + 1 is:

$$\hat{R}_{t+1} = \psi_0\phi_1\hat{W}_{t+1} + \psi_0\phi_2\hat{\bar{W}}_{t+1}^o + \psi_0\beta\hat{V}_{t+2}^T + \psi_1\bar{V}_{t+1}^o + \psi_2\hat{C}_{t+1}. \quad (9)$$

Multiplying (9) by β and subtracting from (8) yields:[10]

$$\hat{R}_t = \beta\hat{R}_{t+1} + \psi_0\phi_1\hat{W}_t + \psi_0\phi_2\hat{\bar{W}}_t^o + \psi_1\bar{W}_t^* + \psi_2\hat{C}_t - \beta\psi_2\hat{C}_{t+1}. \quad (10)$$

This equation was estimated along the lines suggested by Cumby, Huizinga and Obstfeld [1983]. The procedure essentially replaces the forecasted values in equation (10) with that part of the actual values that can be projected from information as of t - 2. The parameters were estimated by two-staged least squares but the covariance matrix was corrected for the moving average error induced by the lag between the time the forecast was made (t - 2) and the actual realization of the variables in periods t and t + 1 (the covariance matrix is discussed in Cumby, et al.). The instruments used for estimating equation (10) for elementary school certifications were the following variables dated as of t - 2 and t - 3: LKEL, LG2EL, LWELR, LOPPWFR, TTEL, TEL, and OPPVEL.

IV. Empirical Results

Tables IV and V present the results of estimating by two-staged least squares the demand curve and the supply curve of trained teachers. Equations (1) and (6) were used as the starting points in the specification search. The residuals from these regressions were tested for serial correlation up to order three using a Lagrange Multiplier (LM) test discussed in Engle (1982). All models rejected the null hypothesis of zero autocorrelation. A first-order serial correlation model was estimated (longer lags were also attempted) and the implied nonlinear common factor restrictions were tested (see Harvey (1981) for a discussion of common factor dynamics). These restrictions were not rejected for the supply equations nor was the null hypothesis that ρ (the autoregressive parameter) equals one.[11] The restrictions were rejected for the demand equations which led to the inclusion of a lagged dependent variable in the demand curve and implicitly a partial adjustment model. The residuals from this model were tested, and the process outlined above was repeated. The null hypothesis that ρ equals one could not be rejected and so both the demand and supply curves are in first differences form.[12] The LM(3) statistic in Tables IV and V test the residuals after the imposition of ρ equals one.

The results of Tables IV and V demonstrate the importance of economic incentives in the market for public school teachers. The secondary school results yield all the expected signs from the model presented above. The estimated short-run effect of wages on the demand for secondary school teachers is negative but not significantly different from zero and implies a very small wage elasticity of demand. Current secondary school enrollment has a significantly positive effect on the demand for teachers, as does expenditures per pupil, although the latter estimate implies a small elasticity. Lagged teachers is significant which implies that a partial or lagged adjustment model is implied by the data. Long-run elasticities of demand can be determined by dividing all the elasticities by $1 - .42 = .58$.[13] This will have the effect of approximately doubling the elasticities.

The estimated supply curve is positively sloped and has a fairly substantial elasticity of .72. This implies that a 20% increase in wages would induce a 14.4% increase in the supply of people willing to teach, holding constant the number of people trained as teachers. The opportunity wage variable has the predicted negative sign and is significant. Although TTHS, the stock of trained secondary school teachers, has the predicted sign, it is not significantly different from zero. The point estimate implies that, on average, a small proportion of the pool of trained teachers actually teaches in any given year.

The results for the elementary school supply and demand curves also strongly support the model and are essentially the same as for secondary school. Both of the demand curves imply small wage elasticities even in the long run. The point estimate of the supply elasticity for elementary school teachers is slightly larger than for secondary school teachers. This is consistent with the much higher proportion of women in elementary school and the typically lower labor force participation rates of women which may tend to make their teacher supply behavior more responsive to wages. The point estimate of the coefficient on TTEL is even smaller than for TTHS which is consistent with a large pool of trained elementary school teachers, of which only a small proportion actually teach in any given year. This suggests that there is a large pool of people who received elementary school certification but who either had no intention of ever teaching or who taught and do not wish to re-enter the market at the current market wage.

The estimates of the secondary school certification decision (equation

10) are presented in Table VI and they represent the response of agents to expected wages at the extensive margin. The two-stage least squares standard errors are directly below the parameter estimates and the heteroscedasticity-corrected standard errors are below them [White (1980)].[14] Column I reports the results of estimating (10) but not holding constant the number of people graduating from college. This specification allows for the possibility that people who receive teacher certification may not otherwise have graduated from college. All the estimates are of the expected sign, however, the point estimate of FG2HS, which is the estimated value of β, is greater than one. This implies that the discount rate, r, solved from $\beta = 1/(1 + r)$ is -.076. The negative point estimate of the discount rate is not an uncommon problem in this type of estimation (for example, Siow [1984] also estimates a negative discount rate) but it still makes the point estimate of little use for determining permanent, long-run effects.

On the other hand, the estimate of the elasticity of FG2HS is .79 (see Table VIII for the means appropriate for determining the elasticities). The relatively large discrepancy between the estimated value of β and the corresponding elasticity measure for β indicates that the first-differenced data is quite volatile over the post-war period. This volatility is a reflection of the large changes that have occurred in the number of certifications over the short time period. If the data were more stable, we would expect the two measures to be quite close together. This indicates that some care must be taken in interpreting long-run-elasticities and it suggests the use of log-first differenced data to help control for this volatility and also for heteroscedasticity. Table IX presents the results of estimating column 1 in percentage-change form; however, we get approximately the same results as for first-differences.

The elasticity of $\hat{R}_t$ with respect to $\hat{W}_t$ is the expected sign and implies a sizeable elasticity, but it is not sharply estimated even with the lower standard errors implied by the heteroscedasticity correction.[15] The point estimate of the short-run elasticity of teacher certification with respect to a permanent change in the expected wage, or alternatively, the elasticity with respect to a transitory increase in the expected wage is 1.36. Using the elasticity estimate of FG2HS yields a point estimate of the long-run elasticity of teacher certification with respect to a permanent change in the expected wage of 6.48 (this is determined by dividing 1.36 by 1 - .79). This may appear to be large, but Freeman's elasticity of supply of first-year engineering enrollments was in the range of one to two in the short run and two to four in the long run.[16] OPPVHS has the expected sign; LOPPWMR is negative, but has no sign implied by the model.

Column II reports the results of adding the dummy variables, DAID and FDAID. This has the dual effect of capturing the effect of the Vietnam War and also the effect of generous loan programs directed toward public school teachers (see Zarkin [1985] for details). These variables appear to have no discernible effect on the number of people receiving secondary school teacher certification. This result is in contrast to Zarkin [1985] which found a significant effect on the number of secondary school certifications, but no significant effect on the number of elementary school certifications. Further research will have to be conducted to settle this issue.

The third column presents the results controlling for the number of college graduates. The value of the F-statistic testing the hypothesis that GRAD and FGRAD are jointly zero is 7.46, which is significant at the .005 level. This statistic is computed from the heteroscedasticity-corrected covariance matrix and is a Wald test, corrected for the degrees of freedom.

The effect of adding graduates to the regression is to swamp the explanatory power of teacher wages and the wage in the alternative occupation (OPPVHS). It appears that much of the responsiveness to changes in the wage in teaching arises through changes in the college-going behavior of people receiving teacher certification. This implies that people who receive secondary school teacher certification may not have otherwise graduated from college.

Turning to Table VII, we see that we have the same qualitative results as in Table VI. The implied short run wage elasticity is large, but the t-statistic is only 1.36 (using the corrected standard errors). The point estimate of the long-run elasticity is larger for secondary school certifications than for elementary school certifications, although because of the large standard errors, probably not too much should be made of this difference.

In contrast to Table VI, the point estimate of β is less than one, which implies that the estimated discount rate is positive ($\hat{r} = .02$). This is certainly encouraging for the model; however, the large difference between the estimate of β and its implied elasticity still indicates large swings in the data.[17]

The inclusion of the dummy variable, DAID, does not significantly change any of the estimated coefficients and is itself insignificant as in Table VI (F-value of 1.21 using the corrected covariance matrix). GRAD and FGRAD are jointly significant as in the secondary school certification equations (F-value of 5.5, which is significant at the .015 level); however, the other parameter estimates, except for LG2EL, are not as sensitive to their inclusion. The point estimate of the long-run elasticity of wages in column III is smaller, but the point estimate of OPPVEL is larger; the implicit discount rate based on the estimated parameter of FG2EL substantially increases.

V. Conclusion

This paper develops a model to study the importance of economic incentives in the recruitment of teachers. The empirical results demonstrate the usefulness of such an exercise. The point estimate of the wage elasticity of the supply of teachers who are already trained is .72 for secondary school teachers and .81 for elementary school teachers. The point estimate of the short-run elasticity of teacher certification with respect to a permanent change in the expected wage is 1.36 and 1.80 for secondary and elementary schools, respectively, where changes in the college-going behavior of students are allowed in response to the expected wage in teaching. These results suggest a substantial wage response in the public school teachers market and demonstrate the importance of economic factors in the supply of public school teachers.

Table I

VARIABLE NAMES AND DEFINITIONS

Variable Name	Definition
DAID	Dummy Variable Equal to One from 1967-1972
ELEXR	Federal Education Expenditures per Student Enrolled in Elementary School ($\times 10^6$)
FDAID	Dummy Variable Equal to One from 1967-1972, Lead = 1
FG2EL	Number of Students Completing Certification Requirements for Elementary School Teaching, Lead = 1
FG2HS	Number of Students Completing Certification Requirements for Secondary School Teaching, Lead = 1
FGRAD	Number of College Graduates, Lead = 1
GRAD	Number of College Graduates
HSEXR	Federal Education Expenditures per Student Enrolled in Secondary School ($\times 10^6$)
LG2EL	Number of Students Completing Certification Requirements for Elementary School Teaching
LG2HS	Number of Students Completing Certification Requirements for Secondary School Teaching
LKEL	Enrollment in Elementary School
LKHS	Enrollment in Secondary School
LOPPWFR	Opportunity Wage for Trained Elementary School Teachers
LOPPWMR	Opportunity Wage for Trained Secondary School Teachers
LWELR	Real Salary (1967 = 100), Elementary School Teachers

LWHSR	Real Salary (1967 = 100), Secondary School Teachers
OPPVEL	Opportunity Wage Foregone by Receiving Elementary School Teacher Certification
OPPVHS	Opportunity Wage Foregone by Receiving Secondary School Teacher Certification
TEL	Elementary School Teachers
TELAG	Elementary School Teachers, Lag = 1
THS	Secondary School Teachers
TSLAG	Secondary School Teachers, Lag = 1
TTEL	Stock of Trained Elementary School Teachers
TTHS	Stock of Trained Secondary School Teachers

(note: see Appendix I for the sources of these variables)

Table II

SUMMARY STATISTICS - LEVELS

(Entire Data Set)

Variable	Mean
LKEL	25446802.3
LKHS	14511062.0
TEL	947099.6
THS	706539.6
LWELR	6299.9
LWHSR	6834.8
LOPPWMR	6296.2
LOPPWFR	4883.0
LG2EL	74649.4
LG2HS	99941.9
GRAD	558735.0
TTEL	1358164.7
TTHS	1768269.3
FG2HS	99217.7
TELAG	938350.1
TSLAG	696326.2
FG2EL	74264.4
FGRAD	571223.8
OPPVEL	5775.0
OPPVHS	6462.0
ELEXR	45.1
HSEXR	69.9

Table III

SUMMARY STATISTICS - FIRST DIFFERENCES

(Entire Data Set)

Variable	Mean
LKEL	233675.8
LKHS	375832.0
TEL	20576.1
THS	23422.2
LWELR	114.8
LWHSR	99.2
LOPPWMR	87.6
LOPPWFR	70.5
LG2EL	973.6
LG2HS	171.2
GRAD	18433.7
TTEL	70602.4
TTHS	93899.1
FG2HS	- 190.6
TELAG	20818.4
TSLAG	24477.1
FG2EL	- 345.5
FGRAD	18218.6
OPPVEL	110.2
OPPVHS	110.3
ELEXR	2.4
HSEXR	3.5

Table IV

ESTIMATES OF THE SECONDARY SCHOOL DEMAND AND SUPPLY CURVE PARAMETERS

Dependent Variable: THS

Variables	Demand Curve	Supply Curve
CONSTANT	8047 (3641) (2915)	6843 (7289) (7400)
LWHSR	- 12.57 (- .05) (21.95) (15.27)	170.59 (.72) (39.11) (32.04)
LKHS	.0179 (.29) (.0055) (.0047)	
HSEXR	159.89 (.02) (80.79) (77.79)	
TSLAG	.4041 (.42) (.1748) (.1326)	
LOPPWMR		- 88.57 (- .33) (32.24) (32.04)
TTHS		.0746 (.30) (.0656) (.0667)
DFE	23	24
R^2	.6922	.5203
LM(3)	2.63	.911

(Note: All variables are entered as first differences. See Table I for variable names and definitions. The elasticity evaluated at sample means is in parentheses to the right of parameter estimates. The two-staged least squares standard errors are in parentheses below the parameter estimates. Heteroscedasticity-corrected standard errors (White [1980]) are below the two-stage least squares standard errors.)

Table V

ESTIMATES THE OF ELEMENTARY SCHOOL DEMAND AND SUPPLY CURVE PARAMETERS

Dependent Variable: TEL

Variables	Demand Curve	Supply Curve
CONSTANT	11652 (3594) (3350)	9900 (10026) (9325)
LWELR	- 13.91 (- .08) (23.46) (24.21)	144.86 (.81) (52.10) (30.67)
LKEL	.0141 (.16) (.0050) (.0042)	
ELEXR	168.83 (.02) (133.0) (132.4)	
TELAG	.3358 (.34) (.2069) (.2256)	
LOPPWFR		- 100.03 (- .34) (49.64) (43.41)
TTEL		.0084 (.03) (.112) (.096)
DFE	23	24
R^2	.5479	.3227
LM(3)	3.53	1.88

(Note: All variables are entered as first differences. The elasticity evaluated at sample means is in parentheses to the right of parameter estimates. The two-staged least squares standard errors are in parentheses below the parameter estimates. Heteroscedasticity-corrected standard errors (White [1980]) are below the two-stage least squares standard errors.)

Table VI

ESTIMATES OF THE SECONDARY SCHOOL CERTIFICATION EQUATION

Dependent Variable: LG2HS

	I	II	III
CONSTANT	2553 (2602) (1034)	2579 (3000) (1569)	- 4876 (4194) (2161)
FG2HS	1.082 (.79) (.325) (.169)	1.086 (.80) (.351) (.209)	.4541 (.33) (.388) (.290)
LWHSR	26.30 (1.36) (29.72) (17.31)	30.08 (1.55) (33.26) (22.04)	- 9.691 (- .50) (35.10) (19.19)
LOPPWMR	- 21.27 (- .92) (36.29) (19.75)	- 25.84 (- 1.12) (41.24) (23.97)	34.87 (1.51) (43.20) (27.76)
OPPVHS	- 28.25 (- 1.71) (34.78) (16.02)	- 28.51 (- 1.72) (39.85) (23.25)	- 5.320 (- .32) (33.99) (20.67)
DAID		- 651.2 (7204) (5257)	
FDAID		2407 (6892) (10154)	
GRAD			.3162 (5.00) (.1712) (.1326)
FGRAD			- .1351 (- 2.19) (.1805) (.1878)
DFE	19	17	17
R^2	.5765	.5778	.6161

(Note: All variables are entered as first differences. The elasticity evaluated at sample means is in parentheses to the right of parameter estimates. The two-staged least squares standard errors are in parentheses below the parameter estimates. Heteroscedasticity-corrected standard errors (White [1980]) are below the two-stage least squares standard errors.)

Table VII

ESTIMATES OF THE ELEMENTARY SCHOOL CERTIFICATION EQUATION

Dependent Variable: LG2EL

	I	II	III
CONSTANT	554.4 (2282) (780)	401.9 (2216) (1130)	- 3654 (2528) (1518)
FG2EL	.9874 (.62) (.3388) (.1969)	1.035 (.65) (.3326) (.2029)	.5572 (.35) (.3107) (.2278)
LWELR	18.24 (1.80) (27.87) (13.41)	20.26 (2.00) (27.31) (17.19)	21.62 (2.14) (20.25) (11.70)
LOPPWFR	- 28.42 (- 1.75) (24.72) (26.44)	- 18.82 (- 1.16) (25.15) (29.96)	- 11.97 (- .74) (18.82) (12.78)
OPPVEL	- 1.984 (- .22) (31.36) (14.76)	- 7.991 (- .89) (30.96) (24.66)	- 13.51 (- 1.51) (23.40) (14.37)
DAID		- 6934 (5529) (7916)	
FDAID		- 2134 (4965) (1978)	
GRAD			.0837 (2.23) (.0776) (.0495)
FGRAD			.0768 (2.10) (.1001) (.0759)
DFE	19	17	17
R^2	.5035	.5690	.6788

(Note: All variables are entered as first differences. The elasticity evaluated at sample means is in parentheses to the right of parameter estimates. The two-staged least squares standard errors are in parentheses below the parameter estimates. Heteroscedasticity-corrected standard errors (White [1980]) are below the two-stage least squares standard errors.)

Table VIII

SUMMARY STATISTICS FOR TABLES VI AND VII

(First Differences, N = 24)

Variable	Mean
LWELR	101.1
LG2EL	1021.8
FG2EL	646.2
LOPPWFR	62.9
OPPVEL	114.3
LWHSR	89.0
LG2HS	1724.7
FG2HS	1263.3
LOPPWMR	74.7
OPPVHS	104.27
GRAD	27245.9
FGRAD	27947.6

Table IX

ESTIMATES OF THE SECONDARY AND ELEMENTARY SCHOOL

CERTIFICATION EQUATIONS

(Log First Differences)

Dependent Variable:

	LG2HS	LG2EL
CONSTANT	- .0027	.0043
	(.026)	(.026)
	(.019)	(.012)
FG2HS(EL)	.5504	.8468
	(.399)	(.331)
	(.291)	(.194)
LWHS(EL)R	2.970	1.697
	(1.94)	(1.68)
	(1.43)	(1.06)
LOPPWM(F)R	- 2.383	- 1.314
	(1.642)	(1.462)
	(1.413)	(1.21)
OPPVHS(EL)	.399	- .385
	(1.632)	(1.809)
	(1.138)	(.749)
DFE	19	19
R^2	.5980	.5175

(Note: All variables are entered as log first differences. The elasticity evaluated at sample means is in parentheses to the right of parameter estimates. The two-staged least squares standard errors are in parentheses below the parameter estimates. Heteroscedasticity-corrected standard errors (White [1980]) are below the two-stage least squares standard errors.)

FOOTNOTES

[1]Freeman usually assumes, as does Zarkin [1985], that there is a two-year delay between the decision to acquire training and actually beginning work. This corresponds to a decision in the junior year of college of a major field.

[2]The number of graduates in education also includes people completing certification requirements for the first time who received a second degree in education, but who have first degrees in another field. See Teacher Supply and Demand in Public Schools, 1973, National Education Association.

[3]Opportunity wages could include the "shadow" value of household time, as well as potential wages in other occupations. Any costs of changing job status are implicitly included in W_t^o.

[4]The special case of this problem and the one usually studied is where F(•) is equal to one.

[5]Of course, the person can always return to school and get additonal education. A more general form of equation (2) could include this possibility.

[6]For a discussion of the relationship of labor force intermittency and occupational choice, see Polachek [1981].

[7]See Appendix I for variable names and definitions.

[8]See Appendix II for the description of the stock of teachers series.

[9]This is also a necessity for solving the entire model since standard solution techniques are based on linearity.

[10]This procedure has been used by Siow [1984].

[11]The test, which is an analog of the likelihood ratio test, is from Gallant and Jorgenson [1979].

[12]Notice that a constant term is included in the first-differences regressions which implies that a time trend is in the levels models. This time trend will capture deterministic changes in all the variables such as the changes in the average wage variables induced by changes in the average age of teachers and in the general population over the post-war period.

[13]This is determined by solving the difference equation for THS.

[14]As noted above, the estimation technique induces a moving average error. However, the covariance matrix used to correct for this is not guaranteed positive definite and, in practice, was not positive definite.

[15]The parameters ψ_0, ψ_1, ϕ_1, and ϕ_2 cannot be separately identified. While it would be useful to recover this additional information, the product of these parameters is sufficient to answer questions regarding the effect of expected wages on the number of certifications.

[16] See Freeman [1976a]. He does not control for first-year enrollments in that paper, so that the two specifications are comparable.

[17] Table IX reports the results of estimating column I for elementary school certifications in log first-difference form; we get approximately the same results as here.

APPENDIX I:

Data Sources

The enrollment data from 1950-1979 represents estimated cumulative enrollment by organization level, elementary and secondary, through the end of each school year. The National Education Association (NEA) in its Estimates of School Statistics includes kindergarten in the elementary school figures and junior high schools in the secondary school enrollments. Since NEA switched from reporting cumulative enrollment to reporting fall enrollment only in the 1972-73 school year, it was necessary to infer the path of cumulative enrollment from data on fall enrollment.

Data on the number of people completing the requirements for teacher certification for the first time for elementary and secondary schools are found in Teacher Supply and Demand in Public Schools (NEA), various issues. The number of graduates in education includes people completing certification requirements for the first time who received a second degree in education, but who received a first degree in another field. Preparational requirements have varied across states and have become more stringent over time. For example, in 1950, only twenty-one states required a college degree, or 120 semester hours of preparation, in order to obtain a standard elementary teaching certificate. (NEA, Teacher Supply and Demand in Public Schools (1950).) In the remaining states, the standard certificate was issued on the basis of ninety, sixty, or thirty semester hours of preparation. Today, all states require 120 semester hours of preparation for a standard teaching certificate. In order to capture those states not requiring a bachelor's degree, data are included for people with less than a bachelor's degree who completed initial certification requirements.

Further adjustment was required due to NEA changes in data collection procedures. The secondary school data from 1950-1965 include people receiving preparation as librarians, as well as people preparing for employment as guidance counselors, school nurses, and other professional support positions. In order to make the data conformable, the 1950-1965 data were multiplied by the average ratio .9638, over the period 1966-1972, of the data excluding these subjects to the data including them.

The total number of people earning bachelor's degrees from 1960 to 1979 was obtained from Projections of Education Statistics to 1986-87, U.S. Department of Education. Data from 1950 to 1959 were obtained from the NCES document, Earned Degrees Conferred, various issues. The data on the number of classroom teachers (full-time equivalent), by school classification are from Estimates of School Statistics, National Education Association, various issues. Real Federal Office of Education expenditures for elementary and secondary education under titles II, III, and V of ESEA and titles III, V, and X of NDEA are from the Digest of Education Statistics, various issues.

The average nine-month salary of classroom teachers is from Estimates of School Statistics, National Education Association, various issues. The salaries foregone by receiving teacher certification are a linear combination of the average salary of entry-level engineers and the average salary of nurses. The opportunity wage foregone by already-trained teachers is a weighted average of the male and female median salary of professional, technical, and kindred workers. The weights reflect the average proportion of men to women of newly-certified teachers over the period 1952-1973. This latter data is found in Teacher Supply and Demand in Public Schools, 1973, NEA. The average proportion of men is .124 for elementary school and .484 for secondary school. The nursing data from 1950-1969 is found in Yett (1975). Observations for 1972, 1975, and 1978 are found in Sloan and Steinwald (1980). An observation for 1981 was derived from the Bureau of Labor Statistics publication Industry Wage Survey: Hospitals. Intervening years were filled in by interpolation. Average annual salaries for entry-level engineers 1961-1979 are from the Handbook of Labor Statistics, Bureau of Labor Statistics, December 1978. Data from 1946, 1956, 1958 and 1961 are from the Occupational Outlook Handbook, Bureau of Labor Statistics, various issues. Intervening years were filled in by interpolation.

APPENDIX II:

The Calculation of the Trained Teachers Series

One of the goals of this study is the development of a time series of trained teachers. No such series exists to my knowledge. Dr. William Graybeal, of NEA research, developed an estimate of the stock of persons meeting minimum certification requirements as of Fall 1981 (see Teacher Supply and Demand in Public Schools, 1981-1982, National Education Association). This number was used as a starting point in my development of the trained teachers series.

A time series of trained teachers can be developed according to the following recursion:

(A.II.1) $$TT_t = (1 - \delta_t)TT_{t-1} + R_t$$

where TT_t is the number of trained teachers as of time t (i.e., the stock of teachers), R_t is the number of newly-certified teachers in period t, and δ_t is the depreciation rate from the pool of trained teachers. A time series for R_t is readily available. Given a time series for δ_t and only one observed value of TT_t, we can recursively generate a time series for trained teachers. The starting point for this recursion is Graybeal's estimate of the stock of trained teachers for Fall 1981, which is 6,062,229.

In order to develop a time series for δ_t we require annual mortality rates for teachers for each year where we take into account the age and sex distribution of teachers. The United States Census for 1950, 1960, 1970, and 1980 provided the age distribution averaged over the experienced civilian labor force and the labor reserve at those four time periods by the classifications elementary/secondary, and male/female.[1] Time periods in between Census years were interpolated using a polynomial in time. The age categories were ages 16-24, 25-34, 35-44, 45-54, and 55-64.

Mortality rate data from 1950-1979 by sex and the five age classifications were taken from Vital Statistics. The depreciation rate for elementary and secondary school males (females) is determined by multiplying the age distribution for elementary and secondary school males (females) by the male (female) mortality rate. The depreciaton rates for total elementary and secondary school were derived by averaging the male and female rates for each school classification. The weights were the ratio of male to female teachers for each year. These ratios were derived from Estimates of School Statistics, National Education Association, various issues. The stock of elementary and secondary school trained teachers as of Fall 1981 is estimated by calculating the average proportion of elementary school certifications to total certifications over the period 1950-1979 (the average is .4318) and multiplying this average by the total stock of persons meeting minimum certification requirements as of Fall 1981 (6,062,229). This number is the starting point used in the recursion formula (equation A.II.1) for the calculation of the stock of trained elementary school teachers.

[1]Since the 1950 Census does not have a breakdown by elementary/secondary or by experienced civilian labor force/labor reserve, the age distribution for 1960 was used for the 1950 distribution. Some details of the 1980 Census have not yet been released and data for the 1970 Census was used instead.

Table A.II.1

THE ELEMENTARY AND SECONDARY SCHOOL

TRAINED TEACHERS SERIES

Date	TTEL	TTHS
1950	471446	607869
1951	514963	675414
1952	561234	731499
1953	606714	780091
1954	648860	823641
1955	693588	867841
1956	740201	918687
1957	789052	977251
1958	837425	1039447
1959	885602	1103888
1960	938652	1173877
1961	989421	1243445
1962	1045630	1319765
1963	1106390	1401866
1964	1176077	1494127
1965	1249184	1596695
1966	1323971	1705214
1967	1404262	1828104
1968	1493594	1953684
1969	1595591	2095590
1970	1702846	2250472
1971	1823609	2417893
1972	1945841	2582072
1973	2065856	2738996
1974	2168636	2872560
1975	2252809	2984739
1976	2331749	3090477
1977	2400105	3180793
1978	2462718	3261139
1979	2518916	3330943

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