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ABSTRACT

This paper presents the methods and results of a probabilistic teacher labor supply model. It uses both qualitative research findings and econometric methods to estimate the number of teachers with specified characteristics under various policy conditions, especially teacher salaries and supervision received. A review of selected relevant literature and descriptions of the econometric techniques and data set provide the framework for the model. Results of the estimations are discussed, and several simulations are used to evaluate the effectiveness of alternative policies and to forecast the teacher market supply. Findings indicate that personal characteristics strongly affect individuals' willingness to teach, and that increasing teacher salaries and/or decreasing supervision of teachers will increase the pool of teacher applicants. This model offers policy makers adaptability in simulating both the desired attributes of teacher candidates and the effect of various policy changes on individuals' probability of choosing a teaching career. References are included. (TE)

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PERSONAL LABOR SUPPLY: AN ESTIMATION
OF A PROBABILISTIC
TEACHER LABOR SUPPLY FUNCTION

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An Estimation of a Probabilistic Teacher Labor Supply Function

ABSTRACT

This paper presents the methods and results of a probabilistic teacher labor supply model. It utilizes both qualitative research findings and econometric methods to estimate the number of teachers with specified characteristics under various policy conditions, especially teacher salaries and supervision received.

A review of selected relevant literature, a description of the econometric techniques employed, and a description of the dataset utilized provide the framework for the model. The results of the estimations are discussed, and several simulations are used to evaluate the effectiveness of alternative policies and the forecast the teacher market supply.

The findings of the preliminary research indicate that individuals' personal characteristics strongly affect their willingness to teach. They also indicate that increasing teacher salaries and/or decreasing supervision of teachers will increase the pool of teacher applicants. It is suggested that further refinement and application of the model using additional data about school characteristics and policies will improve both the flexibility and applicability of the model. This model offers policy makers adaptability in simulating both the desired attributes of teacher candidates and the effect of various policy changes on individuals' probability of choosing a teaching career.

Personal Labor Supply: An Estimation of a Probabilistic Teacher Labor Supply Function

Introduction

Labor supply begins in the mind of the potential worker. This is a fact recognized explicitly in economic theory and implicitly by anyone who has ever made the decision to take a job or pursue a particular career. In economic theory, a person's decision to work depends on his or her attitude toward the job and on the objective rewards and responsibilities associated with the job. Yet, most econometric studies of the supply of teachers (e.g., Zabalza, 1979; Thomas, 1975) simply regress the gross number of teachers against one or a few variables describing the school environment. Such an approach cannot model the individual teacher's decision-making process. Neither can it tell us much about the characteristics of the people who will be attracted to teaching by an increase in teacher salaries.

A probabilistic model of an individual's decision whether or not to teach has the potential of providing a richer, fuller understanding of the teacher supply process. Modern econometric methods allow the estimation of an individual's probability of teaching, given the individual's characteristics and some characteristics of his/her state's educational system. Using such a probability estimate, a researcher can derive an estimate of the number of teachers with specified characteristics that will be supplied under different policy regions. This is a "personal" labor supply model because, unlike previous supply models that predict gross numbers of teachers supplied in response to policy changes, this model builds its predictions on the basis of observed personal career preferences.

This paper presents the method and results of a probabilistic teacher labor supply model and is one of the research activities undertaken in the Southeastern Regional Council's teacher labor market research initiative. Individuals are specified in terms of their age, sex, race, education, earning power, and other sociodemographic characteristics. Their potential workplaces, the school systems, are specified in terms of salaries offered and the amount of supervision teachers receive. The authors believe that the predictive power and flexibility of this model are limited only by the availability of data. Models such as this one should provide policy makers from the local to the national level with a tool to estimate both the size and the composition of the potential teacher supply in response to changes in the conditions under which teachers work.

The paper is organized into six sections. Section One reviews some selected literature that was important in the conceptual development of the model. Section Two describes the general approach taken to the problem, citing both economic theory and qualitative roots of that approach, as well as a brief description of the econometric techniques employed. (A fuller description is provided in Appendix A.) Section Three describes the dataset that was used for analysis and estimation. Section Four presents and discusses the results of the estimation. Section Five presents the results of several simulations employed to evaluate alternative policies. Section Six outlines possible applications of this work, prospects for improving upon it, and policy recommendations drawn from it.

Section One

A Review of Some Pertinent Literature

This study brings together research into the qualitative characteristics of the teacher labor market and the economic theory of hedonic prices. The theory of hedonic prices attempts to model the effect of qualitative aspects of goods and services on their market prices. Qualitative research attempts to investigate people's motivations as they themselves see them. That is, the qualitative researcher tries to find out how decisions are made by asking the decision makers what factors are important to them.

For the purpose of this study, persons choosing occupations were considered to have two options: become a teacher or become something else. Career choices are made on a wide basis of individual perceptions, and any career must be viewed as providing more than just an income stream to an individual, despite what some researchers (see, e.g., Zabalza, 1979) seem to assume. A career choice is surely made on the basis of all of the information about the prospective career available to the decision maker at the time. Teachers might choose their career for many reasons, such as a liking for children, job security, the school work schedule, or other aspects associated with a teaching career (Berry, 1984).

Very few choose teaching as a career because they think that teachers make a lot of money. Other aspects of the job and of the individual seeking it are more important than the income stream. This point is made by Barnett Berry in his paper "A Case Study of the Teacher Labor Market in the Southeast" (1984). Berry interviewed a wide cross section of teachers, principals, and other teacher labor market participants to find out how the market works according to those who presumably know it best. He concluded that factors other than teacher pay are not only important in the decision to become or remain a teacher, but they may be dominant. The other factors cited by Berry include the bureaucracy of the schools, length of vacations and other scheduling conveniences of teaching, characteristics of the locations of individual schools, mobility of spouses, and a sort of mystical feeling that teaching is a "calling," like the ministry. In other words, the decision to teach is based not only on need for income, but on the personal characteristics of the teachers and how well the nonmonetary characteristics of the school environment complement them.

There is fairly substantial economics literature concerned with the question of how qualitative aspects of consumer goods and the labor market affect supply and demand. This literature finds its modern roots in the work of Houthakker (1952), followed by more explicit and systematic treatments by Becker (1965), Lancaster (1966), and Muth (1966). The consumer is characterized by these writers as an intermediate producer who demands not goods *per se*, but their *characteristics* as the raw materials in the home production of utility. Lewis (1969) brought a similar approach to labor market theory, arguing that employers' valuations of workers (i.e., the hourly wage they are willing to pay) are not independent of qualitative aspects of the workers (in particular, the number of hours per week the employees will work). On the supply side, Lewis argued that workers' reservation wage (i.e., the lowest wage a worker will take to work a given job) depends in part on how much time it takes to get to work. Therefore, equilibrium in the labor market depends in part on the adjustment of factors other than wages and quantities of labor.

Sherwin Rosen (1974) presented a general equilibrium treatment of the problem of qualitative valuation of consumer goods. He conceptualized goods as tied bundles of attributes or characteristics, represented in the vector $Z = (z1,z2,...,zn)$, with zi representing the amount of characteristic i present in the good. Consumers value goods according to a valuation function that depends on the shape of the consumer's utility function, his income, and attributes of the good, Z. Producers try to satisfy consumer demand for the attributes in a profit-maximizing manner, and competitive market forces result in prices for the goods that are fundamentally a function of the value (and production cost) of the attributes, not of gross quantities available of tangible goods. From observing the prices of many differentiated goods, producers and consumers can impute the "hedonic prices" of the goods' attributes. Producers then tailor their goods so as to equate the attributes' hedonic price ratios to the ratios of the attributes' marginal production costs. Consumers equate the hedonic price ratios to their subjective marginal rates of substitution among attributes, and they will buy the goods that give them the attributes in the correct proportions.

Rosen's elegant general equilibrium results require quite a bit of imposed structure inappropriate for our present purposes. All that is needed is the realization that consumers value goods for all of their attributes and that they will trade off one attribute for another with a higher marginal utility. For instance, an individual may take a cut in pay in return for a job that seems to be more satisfying in other ways. The willingness of people to make such trades of income for nonpecuniary job satisfaction has been important to the historic development of the teacher work force.

Antos and Rosen (1975) provide econometric evidence of the trade-off between teacher salary and other characteristics of teaching as a job. Their particular emphasis was on determining if white teachers had to be paid more to induce them to teach in black schools. They regressed salary against a number of variables describing characteristics of both schools and teachers, using a 1965 national dataset containing educational data only. The results were consistent with a hedonic wage model in which teachers received a lower salary in exchange for positive characteristics of schools and demanded a higher salary in exchange for tolerating negative school characteristics.

Antos and Rosen's underlying model is quite similar to the one employed in this study. The difference is more of purpose and technique than of concept. Whereas Antos and Rosen are concerned primarily with estimating wages, the present research is designed to estimate supply of teachers. Their paper is a useful companion to this one, illustrative of the potential effect of school characteristics on teacher satisfaction.

Section Two

General Approach and Econometric Techniques

An individual's choice of whether and how much to work is his supply of labor. It is treated in economic theory much like the purchase of a good. Career choice, like consumption choice, is based on the tastes and preferences of the individual and on how well the career's attributes satisfy those tastes and preferences. If a career such as teaching satisfies the needs of an individual in many ways, he or she might be willing to pay the going "hedonic price" for that satisfaction in the form of lower salary or in the form of other negative attributes associated with the job such as oversupervision, overwork, or loss of status.

This paper is an attempt to use econometric techniques to discover which aspects of the teaching career are valuable to individuals and how such valuation varies from individual to individual. It proceeds by observing which individuals are in fact teachers and relates their career choice to their personal attributes and to some attributes of the school systems they serve. This is done by the use of the binary dependent variable technique of logistical regression, Logit (a proprietary computer analysis package), which determines the likelihood of an individual's deciding one way or the other on the basis of various observable variables. The result of this procedure provides a model of labor supply to the teacher market that can be used to test the effectiveness of alternative policies and to forecast teacher supply under various conditions. Market condition simulations based on the model are presented in a subsequent section of this paper.

The conceptual model underlying the regression technique employed here is that an individual's career choice is based on the shape of his/her utility function and on the attributes of the various jobs open. The shape of the individual's utility function, in turn, is determined by his/her personal characteristics, many of which (such as race, sex, age, and marketability in the labor market) can be directly observed or reliably inferred from observable data. The attributes of the teaching career open to an individual (such as pay, bureaucracy, and student characteristics) can also be observed directly or by proxy. These observables, combined with the observed fact of career choice, allow estimation of the conditional probability of any specified individual's choosing teaching as a career.

The thrust of this paper is practical and empirical, not theoretical. The theory of hedonic pricing offers little structure to the problem; it is useful primarily as a general conceptual base. Berry's empirical work also is not very well adapted to econometric tests, but it has been used to inform the choice of variables for study. The method employed here should help the policy maker to assess the likely impact of various policy alternatives on general teacher satisfaction and, hence, on the size and composition of the available teacher labor pool.

In order to simulate the effect of different policy alternatives on the labor supply, it is first essential to obtain unbiased estimates of various parameters describing how individuals' decisions are affected by the policy alternatives. The dataset employed here is composed of observations of many characteristics of thousands of individuals. By creating a new "dummy" variable, equal to one if an individual is a teacher and zero if he/she is not, a researcher can use Logit to obtain the desired parameter estimates.

Logit is very similar in concept to the more familiar technique of ordinary least squares estimation. The major difference is that the dependent variable must have only a finite number of integer values, rather than the continuous range presumed in ordinary least squares estimation. Here the "dummy" variable mentioned before is used as a dependent variable. The parameter estimates that are obtained from the Logit model can be used to calculate the probability that a specified person will be a teacher.

The problem remains of choosing the specific variables to use in the model. The economic theory of hedonic prices indicates that career choice is based on both the attributes of the job and the preferences of the person choosing it. Therefore, a model of the probability that a given person will teach should specify that probability as a function of both personal attributes and the attributes of the teaching employment available.

One can conceive of many personal attributes that might influence the decision of whether or not to teach school. These attributes include age, sex, race, alternative employment opportunities, past experiences with school and teachers, parents' occupations, and other factors, both measurable and unmeasurable. In addition, these and other factors affect a person's opportunity wage, which is the amount of money that the person can expect to make if he/she takes another job besides the one presently held. The opportunity wage, in turn, is both a gauge of a person's worth as an employee (the worker's quality) and a measure of what that individual must give up in order to teach. As such, it may be an important determinant of a person's decision to teach.

Opportunity wage can be estimated using ordinary least squares techniques, and its value can be predicted for all workers and nonworkers on the basis of this estimation. In order for the prediction of opportunity wage to be unbiased, however, it is necessary first to estimate the probability that each person in the dataset would leave home to participate in the labor force at all. Both the reasons for and results of this estimation are presented in Appendices A and B.

To summarize those appendices, the results of this paper depend primarily on the estimation of two equations. The primary one is the Logit estimation of the probability that a person will teach:

(1) $Y = \alpha + s\beta + P\gamma + e$

where Y is an index number that increases in value as the individual's likelihood of teaching increases, S is a bundle of school system characteristics, P is a bundle of the individual's personal characteristics, e is a random error term, and γ, β, and γ are the parameters of interest. Included in the bundle of personal characteristics, P, is the individual's predicted opportunity wage, which is estimated from the parameters of the equation:

$$(2) \quad W = \psi_0 + Z\psi + u$$

where W is the individual's yearly earnings, Z is a bundle of the individual's personal characteristics, u is a random error term, and ψ_0 and ψ are the parameters of interest, which describe the effect of the various characteristics on the individual's yearly earnings. The interested reader may turn to Appendix A for further explanation of the techniques employed.

Section Three

Description of Data

The dataset used was the 1983 Current Population Survey of the U.S. Census Bureau. Observations of Southeast Region residents (based on the twelve member states of the Southeastern Regional Council for Educational Improvement) were extracted and compiled to form a regional dataset upon which the analysis described in this paper was conducted. The use of this dataset carries with it both advantages and disadvantages. Advantages include: its wide coverage of different sectors of the population; its ready availability in machine-readable form; its reliability as a well-financed, professionally gathered survey; the broad range of its questions; and, not least, its large number of observations, which obviate any possible degrees of freedom problems. The large number of observations is not wholly advantageous, however; it is quite expensive to read and manipulate datasets with 18,000 and more observations. Other problems with this dataset for these purposes include: it is not longitudinal, so successive years could not be linked up; it is not completely representative at the state level; and it lacks any indication of curriculum content of individuals' education. It was not possible to investigate the very interesting question of how math and science teachers differ from other teachers because it was not possible to identify math and science teachers from survey information. However, teachers could be identified as a group and other science/math/engineering specialists as a group, and this identification was sufficient for some purposes.

The Current Population Survey (CPS) dataset was merged with a smaller dataset gathered largely from the "Digest of Education Statistics, 1983-84" of the National Center for Education Statistics. This included data on enrollment, racial balance, student/teacher ratio, teacher pay, number of principals and assistant principals, and per pupil expenditure for each state school system in the sample for 1982 and several previous years. This dataset was the source of all school system variables used to analyze the policy alternatives. Less aggregated data would have been desirable; differences between urban and rural systems by state, in particular, would have been useful.

The wealth of information that was available from the dataset allowed the authors to derive interesting and significant results. As noted before, there were two separate stages to the estimation of the supply model: first, a predicted yearly salary for workers was derived for each observation from the wage regression; then the probability of each individual's entry into the teacher labor market was estimated. From this second stage of estimation comes the ability to simulate policy changes and to determine the effectiveness of various types of policies on various classes of people. Each stage of the analysis is described in the sections of this report that follow.

Section Four

Regression Results and Interpretation

The first stage of the analysis involves the estimation of the predicted opportunity wage equation. The procedure begins with the exclusion of all labor market nonparticipants from the data used in the regression. Then a linear OLS model (Equation 2, p. 10) is used to relate the variables chosen to the actual yearly earnings of the individuals in the dataset. Variable names are explained in Table 1, and the results are reported in Table 2.

The variables used as predictors of yearly earnings in the labor market were chosen to reflect human capital considerations and family characteristics as well as the realities of the marketplace. These realities include the fact that whites (RACE = 1), males (SEX = 1), scientists and engineers (SCIMATH = 1), those with substantial income from nonlabor sources (TOTINCOT), URBAN dwellers, and UNION members earn substantially more than those who do not fall into any of those categories. Coefficients can be interpreted as the amount of additional yearly earnings resulting from belonging to the groups; note that it is most lucrative to be male or some sort of scientist, as either one of these factors can add over $6,000 to one's yearly income. Another reality of the marketplace reflected in these regression results is the fact that those who work more weeks per year (WEEKWKD) and longer hours in a typical

TABLE 1

EXPLANATION OF VARIABLES USED

Variable	Explanation
AGESQR	AGEYRS squared
AGEYRS	Individual's age in years
AVGWGT	Teachers' average yearly salary
CLDUN18	Number of children in household under 18 years old
CORRTERM	Mills Ratio (see Appendix A)
DCNEED	Equals 1 if individual has a child under 5
EARNER2	Equals 1 if individual earns less than spouse
EDATTD	Number of years of education completed
EDSQR	EDATTD squared
FEMDC	Equals 1 if the individual is a woman with a child under 5 years old
GRAD	Equals 1 if individual has 19 years or more of school
HOURWKD	Average number of hours worked per week in 1982
INTERCEP	Constant term of the regression
MALEDC	Equals 1 if individual is a male with a child under 5 years old
MARRIED	Equals 1 if individual is married
PREDWAGE	Predicted yearly earnings (opportunity wage)
PRINCIP	Ratio of principals plus assistant principals to teachers
RACE	Equals 1 if individual is white, 0 otherwise
SCIMATH	Equals 1 if individual is in a scientific, mathematical, or engineering profession
SELFEMP	Equals 1 if individual has income from self-employment
SEX	Equals 1 if individual is male, 0 if female
SPOUSINC	Spouse's earned income
TOTINCOT	Amount of nonwage income received by individual in 1982
UNION	Equals 1 if individual belongs to a union, 0 otherwise
URBAN	Equals 1 if individual lives in SMSA, 0 otherwise
WEEKWKD	Number of weeks worked in 1982

week (HOURWKD) will also earn more money. An interesting result of this regression was that self-employment status (SELFEMP) tended to lower predicted earnings. That result may indicate that individuals are willing to pay a positive hedonic price for the benefits of being one's own boss, but it runs counter to the usual assumption that the greater risk attached to self-employment will yield an earnings premium. The possibility of

TABLE 2

REGRESSION RESULTS FOR EARNINGS OPPORTUNITY COST

DEPENDENT VARIABLE: TOTEARN, OR TOTAL EARNED INCOME IN 1982

F VALUE	PROB>F
548.525	0.0001

ADJUSTED R-SQUARE 0.4614

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER+0	PROB > !T!
INTERCEP	1	-28407.994	2023.740	-14.037	0.0001
AGEYRS	1	506.647	33.258504	15.234	0.0001
AGESQR	1	-8.331493	0.808112	-10.310	0.0001
SEX	1	6218.374	374.520	16.604	0.0001
RACE	1	1788.559	221.135	8.088	0.0001
URBAN	1	1808.546	174.054	10.391	0.0001
UNION	1	2900.502	486.047	5.968	0.0001
SCIMATH	1	6309.003	651.002	9.691	0.0001
TOTINCOT	1	0.128024	0.036315	3.525	0.0004
WEEKWKD	1	212.372	5.908353	35.944	0.0001
HOURWKD	1	150.421	7.066629	21.286	0.0001
SELFEMP	1	-2825.563	281.780	-10.028	0.0001
MARRIED	1	1535.646	189.800	8.091	0.0001
SPOUSINC	1	-0.045119	.006480636	-6.962	0.0001
MALEDC	1	665.639	339.440	1.961	0.0499
FEMDC	1	595.693	432.867	1.376	0.1688
EDATTD	1	-448.797	177.554	-2.528	0.0115
EDSQR	1	62.008634	7.354108	8.432	0.0001
CORRTERM	1	786.129	1205.244	0.652	0.5142

strong collinearity between self-employment status and hours worked introduces an element of ambiguity into the finding. Further research into the relation between earnings and self-employment seems to be needed to clarify the effect.

Family characteristics serve to indicate a worker's motivation and stability, factors important both to the worker himself and to the employer as an indication of what to expect. In general, being MARRIED and being a man with a small child (MALEDC) are motivators and stabilizers and result in higher earnings. Spouses earning large incomes (SPOUSINC) reduce the motivation to work and increase the chance that the worker will leave his/her present job if the spouse gets a better job offer. Finally, women with small children (FEMDC), although motivated to work hard to provide for their families and unlikely to take a low-paying job because of the value of their own day-care services, will still not be expected to earn as much as their male counterparts, as shown by the statistical insignificance of the FEMDC coefficient.

Finally, there are the human capital variables, which indicate the individual's experience and education. Both AGEYRS, which appears as a proxy for experience, and education (EDATTD) were included in their squared forms (AGESQR and EDSQR) as well, in order to allow for a nonlinear effect. As might be expected, the effect of age on earnings is to make them increase, but this increase takes place at a decreasing rate, as indicated by the small negative coefficient on AGESQR. Experience may be beneficial in a job, but the big increases in pay that are the result of experience occur in the earlier years when the marginal impact of experience on work performance is at its greatest.

The coefficients on the education variables appear at first glance to be perverse. How can one explain the negative coefficient on years of education attended (EDATTD)? The answer becomes clear when it is considered in conjunction with the EDSQR (years of education squared) variable and a few numbers are plugged in. The coefficient on EDSQR is positive and about one-seventh of the value of the coefficient on EDATTD. This means that a person who has seven or fewer years of education will be no better off than someone who has no education at all. But as years of education increase from seven, the payoff from education increases as years of education squared. By the time the person has received a high school diploma (13 years of education, including kindergarten), he has added $4,628 to his predicted yearly salary. A college education (17 years) adds an additional $5,640 a year, ceteris paribus. Therefore, the regression equation shows that not only is education valuable, but the higher the level of education, the higher the value.

From this analysis of the results summarized in Table 2, it is apparent that there is reason to have confidence in the estimates obtained of salaries available to individuals in the labor market. Parameter values are reasonable in both sign and size. This confidence is further bolstered by the value of adjusted R-square, 0.4614, which is quite good for cross-sectional analysis. All coefficients are significantly different from zero to at least a 95 percent confidence level (except FEMDC, explained above, and CORRTERM), and all but three are significant at the 99.99 percent confidence level.

The Decision to Teach

Table 3 presents the results of the Logit run used in the generation of the simulations in Tables 4A-D and 5 (see Section 5). The sample used was composed of all college graduates in the CPS for the 12 southeastern states. Overall goodness-of-fit measures such as the likelihood ratio statistic and the fraction of concordant pairs show that the explanatory value of the regression is excellent, and the signs of the parameters shed much light upon the questions of concern here.

In general, the results indicate that an individual's personal characteristics are stronger determinants of the desire to teach than are the available measured characteristics of the school systems that might hire him/her. Of the school system variables, the average salary paid teachers in the respondent's state (AVGWGT) and the amount of supervision teachers receive (presented by PRINCIP, the ratio of principals plus assistant principals to teachers) were both found to be statistically significant determinants of the decision to teach. Of the personal variables, the most important determinants of predicted probability of teaching were the respondent's sex, race, predicted market or opportunity wage (PREDWAGE), whether or not he/she lives in an urban area (URBAN), earning status within the family (EARNER2), and whether or not he/she has education beyond the baccalaureate level (GRAD).

Regression Results

Personal factors seem to dominate the decision to teach. Results summarized in Tables 4A-D (see Section 5) show that by far the most important determinant of a decision to teach is the person's sex. The SEX dummy variable was set equal to 1 if the respondent was a man, 0 for a woman, so the negative coefficient indicates that women are more likely to be teachers. It is, of course, no surprise to anyone that many teachers are women. But note that the effect of being female is amplified further

TABLE 3

REGRESSION RESULTS--TEACHER MARKET PARTICIPATION DECISION

LOGISTIC REGRESSION PROCEDURE

DEPENDENT VARIABLE: TEACH, WHICH EQUALS 1 IF PERSON TEACHES K-12

2741 OBSERVATIONS
2344 TEACH = 0
397 TEACH = 1

CONVERGENCE OBTAINED IN 7 ITERATIONS R = 0.471.

MAX ABSOLUTE DERIVATIVE = 0.1595D-07 -2 LOG L = 1735.56.

MODEL CHI-SQUARE = 532.07 WITH 14 D.F. (-2 LOG L.R.) P = 0.0.

VARIABLE	BETA	STD. ERROR	CHI-SQUARE	P
INTERCEP	-6.27773471	1.91929001	10.70	0.0011
PREDWAGE	0.00007827	0.00001215	41.49	0.0000
SEX	-2.41526687	0.18675240	167.26	
SPOUSINC	-0.00001004	0.00000461	4.74	0.0295
EARNER2	1.00296095	0.17763755	31.88	0.0000
DCNEED	-0.38899100	0.19819260	3.85	0.0497
RACE	-1.09100949	0.16955755	41.40	0.0000
URBAN	-0.97903872	0.13426144	53.17	0.0000
GRAD	0.34814236	0.13784040	6.38	0.0115
AGEYRS	0.04586176	0.02814822	2.65	0.1033
AGESQR	-0.00108624	0.00058312	3.47	0.0625
SELFEMP	-1.21785377	0.33991949	12.84	0.0003
PRINCIP	-22.96146314	11.72421131	3.84	0.0502

FRACTION OF CONCORDANT PAIRS OF PROBABILITIES AND RESPONSES :0.823

RAND CORRELATION BETWEEN PROBABILITY AND RESPONSE :0.661

by the fact that being the second, or lesser, wage earner of the family (EARNER2), as many women are, also increases the likelihood that teaching will be the chosen career. Still, for those whose spouses have a very high income, teaching becomes less attractive as is indicated by the negative coefficient on amount of spouse's income (SPOUSINC).

Both male and female respondents with small children were less likely to be teachers, as indicated by both the negative and significant coefficients of the DCNEED variable. When combined with the results from the labor force participation regression in Appendix B, this result indicates that in the majority of cases men with small children were likely to seek more lucrative employment outside of teaching; women tended to leave work altogether to stay home and take care of the new child. In the regression in Appendix B, women with small children were found to be less likely to be in the labor force. In contrast, the effect of having a small child on men's choice of whether or not to work was insignificant.

That men and women who do teach are in fact likely to be able to find more lucrative job opportunities elsewhere is again indicated in this regression by the positive coefficient on the respondents' predicted opportunity wage variable (PREDWAGE). The variable PREDWAGE was constructed by multiplying the coefficients derived in the salary OLS regression (Equation 2) by the values of the corresponding variables for each individual and adding to get an unbiased estimate of what an individual with those attributes should be able to earn in the marketplace. Its positive coefficient in the teacher regression indicates that people who should be able to command high salaries are more likely to be teachers. Note that this relationship holds with greater than 99 percent confidence even though the sample population is composed entirely of college graduates; therefore, it is not just their generally superior educational attainment that makes teachers superior in their earnings potential. This result may indicate that teaching has greater intrinsic rewards than many other professions.

Other personal characteristic variables that have the expected signs in the teacher regression include age and age squared, which indicate that the likelihood of teaching increases for a time, then decreases as people age. The coefficient on race indicates that nonwhite college graduates are more likely to teach than are whites. Also, those people with graduate (GRAD) degrees (Masters' or higher) are more likely to be teachers. Urban college graduates, with their more varied opportunities, are less likely to find teaching an attractive career. Finally, people with self-employment income are considerably less likely to be teachers, a finding that is consistent with Berry's finding that teaching appeals to risk-averse individuals (Berry, p. 73).

The results indicate that the average salary offered teachers is the most important measurable policy determinant of predisposition to teach, among the variables included in this study. The results are consistent with Berry's findings that "more money might not necessarily attract those presently choosing to teach" (p. 73). These results indicate that the average salary offered teachers is the most important policy determinant of predisposition to teach. Only one other policy variable, the principal/teacher ratio, was found to be a statistically significant predictor of desire to teach. The regression reported in Table 3 has been stripped of most of the policy variables found to be insignificant in previous, more inclusive runs so that it could be used for the predictions of policy effects found in Tables 4A-D and 5 (see Section 5). Variables tried and rejected include changes over the last four years in enrollment, teacher salary, per pupil expenditures, and black enrollment. Student/teacher ratio was also found not to be statistically significant. The fact that these policy variables were not significant is important, although the reason for the finding may have much to do with the level of aggregation of data used for those variables. More study based on less aggregated measures of classroom size and other policy variables is needed.

The ratio of principals plus assistant principals to teachers (PRINCIP), hereafter referred to as the principal/teacher ratio, was interpreted as a proxy for the degree of supervision and bureaucratic control that teachers face. The negative value of the coefficient indicates that the more bureaucracy teachers must deal with, the less attractive teaching is for potential candidates. This finding confirms Berry's conclusion that "the bureaucracy of today's schools has influenced the low morale present among public school teachers" (p. 78). The problem seems to be that teachers feel that they are not being treated as responsible professionals by the administration. As one teacher in Berry's study said, "I don't like people checking up on me" (p. 61).

It seems that policy makers may be able to attract and retain teachers effectively if they raise teachers' salaries and lower their bureaucratic burden. With regard to the often-stated goal of weeding out the bad teachers and rewarding the good ones, these results indicate that perhaps more emphasis should be placed on evaluating the effectiveness of principals rather than teachers; by weeding out the principals who alienate responsible, capable teachers, it might be possible to retain higher quality teachers. The next phase is to try to gauge how effective either of these policies will be. Also, how will these policies affect the composition of the teacher labor force? These questions are dealt with in Tables 4 and 5.

Section Five

Simulations of Policy Change

Elasticities of Probability to Teach

Table 4 is presented in four subtables, 4A through 4D. All four show elasticities of change in the probability that individuals with the characteristics described will be teachers with respect to changes in teachers' average salaries or the principal/teacher ratio. Lower elasticities indicate that the individuals are less likely to change their minds about teaching in response to a policy change. Negative elasticities indicate that a rise in the value of the policy variable elicits a decrease in predisposition to teach.

Note that these are elasticities of probability change, unlike elasticities of supply; a value of 2, for example, does not indicate that a 10 percent change in average teacher earnings will result in a 20 percent increase in teacher supply. Instead, a value of 2 indicates that an _average_ person of the defined group will be 20 percent more likely to teach if earnings increase by 10 percent. Nonaverage members will in general have a different (greater or lesser) reaction. Thus, the numbers are more significant as comparative, rather than absolute, values. This method of interpretation is consistent with an interpretation of the change in teaching probability as corresponding to a change in the value of the potential teacher's utility index. While the level of utility associated with a job attribute determines the likelihood that a person will take the job, the actual cardinal value of the utility index is

ELASTICITIES OF PREDISPOSITION TO TEACH
WITH RESPECT TO VARIOUS POLICY VARIABLES

TABLE 4A

ELASTICITIES OF PREDISPOSITION TO TEACH WITH RESPECT TO AVERAGE TEACHER EARNINGS AND PRINCIPAL/TEACHER RATIO FOR VARIOUS POPULATION GROUPS

POLICY	ALL	MEN	WOMEN	WHITES	NONWHITES	GRAD SCHOOL
Average Teacher Earnings	2.663	2.79	2.324	2.69	2.315	2.541
Principal/ Teacher Ratio	-1.12	-1.17	-1.00	-1.13	-.992	-1.08

TABLE 4B

ELASTICITIES OF PREDISPOSITION TO TEACH WITH RESPECT TO AVERAGE TEACHER EARNINGS AND PRINCIPAL/TEACHER RATIO FOR VARIOUS POPULATION GROUPS

	FIRST EARNER	SECOND EARNER	URBAN	RURAL	SELF-EMPLOYED	NONSELF-EMPLOYED
Average Teacher Earnings	2.719	2.498	2.735	2.534	2.822	2.633
Principal/ Teacher Ratio	-1.14	-1.07	-1.15	-1.08	-1.18	-1.11

TABLE 4C

ELASTICITIES OF PREDISPOSITION TO TEACH WITH RESPECT TO AVERAGE TEACHER EARNINGS AND PRINCIPAL/TEACHER RATIO FOR VARIOUS INCOME GROUPS

	$15K	$20K	$25K	$30K	$35K	$40K
Average Teacher Earnings	2.601	2.68	2.59	2.466	2.759	2.688
Principal/Teacher Ratio	-1.1	-1.13	-1.1	-1.06	-1.16	-1.13

TABLE 4D

ELASTICITIES OF PREDISPOSITION TO TEACH WITH RESPECT TO AVERAGE TEACHER EARNINGS AND PRINCIPAL/TEACHER RATIO FOR VARIOUS AGE GROUPS

	21 Years	25 Years	30 Years	35 Years	40 Years
Average Teacher Earnings	2.747	2.695	2.625	2.596	2.572
Principal/Teacher Ratio	-1.15	-1.13	-1.11	-1.1	-1.09

meaningless.

Tables 4A and 4B indicate that men, whites, dominant wage earners within families (First Earners), urban dwellers, and those with some self-employment income are most responsive to changes in teacher earnings. This is to be expected since these groups have the most employment alternatives to choose among. For the same reason, it is not surprising that these same groups are also more responsive to changes in the principal/teacher ratio than is the population as a whole. Therefore, raising teacher pay and decreasing the supervision of teachers will tend to enrich selectively the teacher labor pool in white, male, urban, primary earners or in persons who have at least one of these characteristics.

Table 4C simulates how the two policy variables will affect groups of differing predicted yearly incomes. The predicted income of a person reflects the person's marketability in the labor market. Theory predicts that those with the most labor market choice, i.e., those with the highest predicted wages, should also have the highest elasticities of teaching probability with respect to the policy variables. Instead, no monotonic relationship between predicted income and the calculated elasticities is observed. There is a peak in both elasticities at an income of $20,000 and then a sharp drop, followed by another peak at $35,000.

It is interesting to note that the lowest elasticities occur around the average teacher's predicted income of $25,700 and that the highest elasticities are just above and below the lowest. Perhaps this result can be understood in light of Berry's qualitative study; he suggests that teaching is a "calling," not a normal job, that "for many, teaching provides similar rewards to those found in religion" (p. 69) and, therefore, that mere monetary reward does not play much of a part in attracting new teachers to the profession. This is another way of saying that the decision to teach is expected to have a low elasticity with respect to teacher salary or working conditions. The results in Table 4C suggest that there might be something special about people whose sociodemographic profiles put them in the $25-30,000 predicted income group that makes them more susceptible to the "calling" and therefore less influenced by conditions of employment. Those in slightly higher and lower predicted income brackets are the ones who are most likely to be wooed by higher salaries and more autonomy.

Table 4D shows that younger individuals are more apt to be influenced by changes in salary and working conditions than are their elders. Again, the range of choice for younger people is wider, and their costs of job change (e.g., loss of retirement benefits) are lower than their elders'. These results indicate that higher wages and less supervision will tend to be most effective in attracting and retaining younger teachers. Whether or not this is desirable is a decision that policy makers must make; perhaps the younger teachers' lack of experience would be more than made up for by their extra energy and optimism. In any case, it is clear that most college students are young, and if it is the desire of school boards to attract college students to education, these results indicate that offering higher salaries and less bureaucracy may be effective in doing so.

Effectiveness of Alternative Policies

Table 5 uses the results of the teacher Logit model to address a different question from those addressed in Tables 4A-D. Many normal lifetime events can lessen the attractiveness of a teaching career. Most teachers are women (80 percent in the CPS sample), and many (52 percent in the sample) are not the primary wage earners in their families. As secondary wage earners, they would be expected to move with their husbands as their husbands change jobs. The family's prime earner may get a substantial raise, lessening the need for a secondary source of income. The arrival of a child may also affect a woman's attitude toward working outside the home. Any of these events might result in the teacher's

TABLE 5

EFFECTS OF POLICY CHANGES ON TEACHER ATTRITION
DUE TO VARIOUS LIFETIME EVENTS

		20% HIGHER PAY		LOWER PRIN/ TEACH RATIO		BOTH CHANGES	
	STATUS QUO PCT DROP	PERCENT DROP	EFFECT INDEX	PERCENT DROP	EFFECT INDEX	PERCENT DROP	EFFECT INDEX
EVENT							
Having a Child	-11.5	-9.32	0.186	-10.7	.0687	-8.38	.2684
Moving to SMSA	-50.7	-43.5	.1413	-48.1	0.504	-40.1	.2089
Spouse Income Rises 50%	-6.58	-5.32	.1921	-6.11	.0713	-4.76	.2763

leaving teaching, either to stay home or to get a different job. Since experience is a valuable asset in a teacher, policy makers may wish to discourage this tendency to leave teaching. What policies are most effective toward this end? This is the question that Table 5 helps to answer. To focus on the effect of each of these events on teachers, as opposed to the general population, the numbers used to calculate the values in Table 5 are averages for teachers in the Southeastern United States.

On the left side of Table 5 are listed the three events whose effects we wish to study: having a child, moving (in this case from a rural area to an SMSA), and a large (here, 50 percent) increase in the spouse's income. Each reduces the likelihood that a person will be a teacher. The first column shows the percentage drop in the respondent's likelihood to teach that will result from each of the three events if there is no change from the present (1982) average salary of teachers or principal/ teacher ratio. The second, fourth, and sixth columns show the same figure for three different policy regimes: 20 percent higher average teacher salary, 20 percent drop in principal/teacher ratio, and both policies implemented at once, respectively. The third, fifth, and seventh columns show the proportional drop in the attrition rate attributable to the three policy regimes in this simulation. This figure is called the "effect index" for each of the policy regimes. The larger the effect index, the more effective the policy is in preventing teacher attrition.

Table 5 indicates that an across-the-board increase in teacher pay would be an effective policy in addressing the problem of teacher attrition due to the events described in the table. It is most effective in this simulation in decreasing the likelihood that a teacher whose spouse has gotten a raise will leave teaching. It is least effective in dissuading teachers in urban areas from leaving teaching. The results are similar for the drop in principal/teacher ratio, although the effectiveness of this policy is considerably lower across the board than that of raising teacher salaries. (Of course, the costs involved in implementing the different policies will differ as well; giving raises to teachers is certainly more expensive thar firing assistant principals, so the latter policy may well be the more cost-effective.) The effect of both policies being implemented separately is somewhat smaller than that of both policies being implemented together in each case, suggesting that there might be some synergy between the policies.

Forecasts of Market Condition

The teacher labor supply model can also be used to forecast the total supply of teachers that can be expected from a specified population. As a forecasting tool, the model can be used to estimate supply of teachers or teacher-training candidates for the region, for a state or locality within the region, or for a program area within a university system. In conjunction with the writing of this report, one of the authors (Bird) has developed a microcomputer program that allows the user to easily manipulate conditions and policies affecting the market and see the results in terms of a forecast teacher supply. The program is a straightforward application of the parameters estimated in Table 3.

If characteristics of the college-educated population of the Southeast are entered into the model along with the 1983 regional average teacher pay level ($17,463) and the principal/teacher ratio (.0547), the predicted probability that a college-educated resident of the region would seek employment as a public school teacher was estimated to be .0218932. Applying this probability to the estimated number of persons in the college-educated pool of potential workers in the Southeast (5,823,074), the expected value of the total supply of teachers is 127,485. Table 6 shows a sample printout of the policy simulation program that illustrates this estimate. This estimate might be interpreted as the expected value of the number of persons who would choose to enter teaching if each member of the specified population group were given the opportunity to revise his/her career decision without any transactions costs. That revision of choices, of course, would not happen since transactions costs are present and significant. Having chosen a career, a person may remain in it even though he/she may come to regret the choice. Since the forecast number

TABLE 5

EXAMPLE OF MARKET CONDITION SIMULATION

Preliminary Policy Analysis Model for the Teacher Labor Market

Teacher Labor Market Individual Supply Probability Model

Specify values for the following individual characteristics:

Alternative Earning Opportunity (in dollars per year)	19,755.39
Sex (1 = male; 0 = female)	.55673
Income of Spouse (in dollars per year; 0 if unmarried)	15,629.64
Earner Status (0 if primary earner; 1 if second)	.31047
Child Care Need (0 = no; 1 = yes)	.10872
Race (0 = nonwhite; 1 = white)	.89493
Urban Residence (0 = no; 1 = yes)	.55491
Masters Degree Completed (0 = no; 1 = yes)	.40825
Age (in years)	38.8572
History of Self-Employment (0 = no; 1 = yes)	.10434

Specify values for the following school characteristics:

Average Pay of Teachers	17,463
Ratio of Principals (including assistants) to Teachers	.0547

The probability that an individual member of a group having the above mean characteristics will enter teaching is .0218932

To estimate total teacher supply enter the estimated number of persons in the group having the specified mean characteristics: 5,823,074

Note: The estimated college-educated/work-eligible population of the Southeast is 5,823,074

The expected value of the total supply of teachers is 127,486

Note: In the Southeast 507,045 persons were employed as public school teachers in 1982-83

Demand for Teachers:

Enter Total Number of Students to be Served	9,522,831
Enter Desired Student/Teacher Ratio	18.78
Total Number of Teachers Required	507,073
Market Condition: Expected Supply Minus Demand	-379,587

Note: Negative value indicated shortage of teachers
percentage difference between supply and demand -74.9%

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who would freely choose teaching is less than the current number (507,045) of persons actually working as teachers, the difference might indicate the number of teachers regretting the past decision to teach, even though transactions costs prevent revising the decision now.

Since the estimate here is a stock estimate for the labor supply, it indicates the direction and eventual cumulative total of labor supply flows over time, without indicating the rate of flow. It means that if market conditions are not altered, shortages of teachers will emerge over time as attrition removes present teachers.

The model reveals that teacher supply is quite sensitive to changes in teacher salary level. If the amount entered in the model is raised to $25,420, it was found that the expected value of the total supply rose to 507,877. At that level, the current demand for teachers in the region would be met. The market could be considered to be in an equilibrium. Raising the average salary beyond that level would produce a surplus of persons seeking jobs as teachers. The result of this simulation is shown in Table 7.

TABLE 7

EXAMPLE OF SIMULATION WITH HIGHER SALARY

Preliminary Policy Analysis Model for the Teacher Labor Market

Teacher Labor Market Individual Supply Probability Model

Specify values for the following individual characteristics:

Alternative Earning Opportunity (in dollars per year)	19,755.39
Sex (1 = male; 0 = female)	.55673
Income of Spouse (in dollars per year; 0 if unmarried)	15,629.64
Earner Status (0 if primary earner; 1 if second)	.31047
Child Care Need (0 = no; 1 = yes)	.10872
Race (0 = nonwhite; 1 = white)	.89493
Urban Residence (0 = no; 1 = yes)	.55491
Masters Degree Completed (0 = no; 1 = yes)	.40825
Age (in years)	38.8572
History of Self-Employment (0 = no; 1 = yes)	.10434

Specify values for the following school characteristics:

Average Pay of Teachers	25,420
Ratio of Principals (including assistants) to Teachers	.0547

The probability that an individual member of a group having the above mean characteristics will enter teaching is .0872181

To estimate total teacher supply enter the estimated number of persons in the group having the specified mean characteristics: 5,823,074

Note: The estimated college-educated/work-eligible population of the Southeast is 5,823,074

The expected value of the total supply of teachers is 507,877

Note: In the Southeast 507045 persons were employed as public school teachers in 1982-83

Demand for Teachers:

Enter Total Number of Students to be Served	9,522,831
Enter Desired Student/Teacher Ratio	18.78
Total Number of Teachers Required	507,073
Market Condition: Expected Supply Minus Demand	-804
Note: Negative value indicated shortage of teachers percentage difference between supply and demand	0

Section Six

Conclusions, Prospects, and Policy Recommendations

The economic theory of hedonic pricing indicates that personal attributes of potential teachers, teacher pay, and other attributes of school systems will determine how many and which people will decide to become teachers. Berry's qualitative research investigated which attributes may be important to teachers. This paper represents a first step in forging a new tool for policy analysis that synthesizes the results of theory and qualitative research to predict both the size and character of teacher supply responsiveness.

The results reported here indicate that individuals' personal characteristics strongly affect their willingness to teach. Results concerning various policy effects are sparse at this stage due to the lack of specific data. Berry's study indicates that such school characteristics as school location (urban versus rural), parental support, physical plant, and school requirements (such as out-of-field teaching, coaching, and lunchroom or bus duty) are important to teachers' job satisfaction. Future users of the research technique outlined in this paper should try to obtain information on these variables that can be merged with the CPS or other suitable dataset.

When better data are used, the flexibility and applicability of the model should also improve. For example, Berry's research indicates that problems of rural and urban schools are often different and that the people who teach in urban systems differ in many respects from those who teach in rural systems. Data on how policy variables such as teacher salary, supervision, expenditure on school facilities, and student/teacher ratio vary from urban to rural areas within each state would enable researchers to differentiate between the best policies for urban and rural systems.

At this stage in the investigation, it seems safe to conclude that there is strong evidence that both salary and supervision have an effect on the supply of teachers. Present results strongly indicate that raising teacher salaries and/or lowering the amount of supervision they receive would increase the size of the pool of teacher applicants. Furthermore, this research indicates that such policy changes would result in a larger percentage of white, male, urban applicants for teaching jobs (see Table 4A and B). The conclusion that an average salary level of about $25,400 would result in teacher labor market equilibrium must be considered tentative at best. Specific dollar figures may be debated, but there is no doubt that this model strongly indicates that more people would choose to be teachers if the salary were higher.

This paper reports the methods and results of a novel and potentially useful technique for studying the teacher labor market. By using logistical and ordinary least squares regression techniques, the authors have modeled the individual person's decision-making process and derived a probability that a specified type of person would take a teaching job specified in terms of salary and an index of supervision. The advantage of this technique is its flexibility. A policy maker can, within the limits of the model, specify any desired "target" teacher candidate and simulate the effect of certain policy changes on the "target" type's probability of teaching. Such information should be useful to policy makers at all levels of government.

APPENDIX A

ECONOMETRIC SPECIFICATION

Imagine that a person's attitudes toward choosing teaching as a profession can be summed up by a utility index, a variable called Y which has a greater value, the more favorably disposed the person is toward teaching. From the foregoing discussion, it can be concluded that Y is a function of a vector of school characteristics **S**, a vector of personal sociodemographic characteristics **P** (including the person's wage $\underline{W}$), and a disturbance term e, which contains the nonmeasurable inputs into the utility function modeled as a random variable:

$$Y = \alpha + \mathbf{S}\beta + \mathbf{P}\gamma + e \qquad \text{(A1)}$$

where α is a constant. This specification has two problems of missing data. First, the utility index Y cannot be observed: only whether or not a person is in fact a teacher can be observed. Secondly, $\underline{W}$ is not observed for anyone who is not working. These problems will be dealt with one at a time.

The first problem can be solved in the usual way with binary dependent variable estimation techniques by constructing an observable "dummy" variable y, which is equal to 1 if the person teaches and equal to 0 otherwise. Since the variable Y in Equation (A1) is an index of attitudes toward teaching, it will be assumed that there is some threshold value of Y, which is called A, such that if Y exceeds it, the person will be a teacher. In terms of y:

$$y = \begin{cases} 1 \text{ if } Y > A \\ 0 \text{ if } Y \leq A \end{cases} \qquad \text{(A2)}$$

Define $J = \alpha + S\beta + P\gamma$, and substitute (A1) into (A2) to get:

$$\text{(A3)} \qquad y = \begin{cases} 1 \text{ if } e > A - J \\ 0 \text{ if } e \leq A - J \end{cases}$$

Now divide through by the standard deviation of e, called s, to normalize e's variance to one. This allows the use of the standard logistic cumulative density function, $F(t) = \exp(t)/(1+ \exp(t))$, to get a probability of y equalling 1 or 0:

$$\text{(A4)} \qquad \begin{cases} P(\text{Teach}) = P(y=1) = P(\ e > A-J\ ) = 1 - F\{(A-J)/s\} \\ P(\text{Don't Teach}) = P(y=0) = F\{(A-J)/s\} \end{cases}$$

Now, use Maximum Likelihood Estimation to find parameter estimates for $(A - \alpha)/s$, β/s, and γ/s. The lack of identification for the parameters s and A is no problem, since they are not needed to estimate the probabilities that will be the final results. All now needed will be the normalized parameters, which is fine since those are the only ones that can be estimated. The likelihood function to be maximized will be:

$$\text{(A5)} \qquad L = \prod_{i \notin T} F\{(A-J_i)/s\} \prod_{i \in T} [1 - F\{(A-J_i)/s\}$$

where i indexes each observation (person) in the dataset, and T is the set of teachers. Once these parameter estimates are derived, it is possible to compute the probability that a person will be a teacher, given the observed personal and school characteristics. By manipulating the policy control variables, one can estimate how these probabilities will change, and by manipulating the personal characteristics variables, one can assess the different impacts of policies on different classes of people.

Solving the problem of missing wage data is a bit more tricky, but here again, accepted econometric techniques provide aid, thanks to Heckman (1976, 1979). For a complete and lucid explanation of how this problem has been solved in the past, the reader is referred to Chapter 4 of Mark R. Killingsworth's book, Labor Supply. Another excellent general reference is Judge, et al. (1980), Chapter 14.

The problem is this: Predicting individuals' market wage by regressing actual earnings on personal characteristics is complicated by the fact that some observations in a dataset will show actual earnings equal to zero, corresponding to the set of people who are not in the labor force. This creates a dilemma as to what to put down for their dependent variable, wage. Setting their wage to zero will bias the regression downward, since most of these people could earn money if they chose to work. Trying to avoid the problem by leaving out the observations will also bias the regression, since the decision whether or not to work is certainly related to the wage a person could make if he/she chose to enter the labor force.

The way out of this dilemma is first to estimate the amount of bias resulting from leaving out the nonworkers, then to introduce a term in the labor supply equation that uses that estimate to correct for the bias. With this term in the wage or labor supply equation, it is possible to estimate it without bias by using only the observations for workers. This technique is referred to in the literature as bias-corrected regression. First a probit or logit is run (using all observations) on the decision of whether or not to work in order to get the estimate of bias, $\hat{\lambda}$. Following the procedure of Heckman, it is customary to assume that the likelihood that a person will work is a function of various observable characteristics of both the person and the labor market faced, summed up in the vector **X**. These characteristics can be thought of as determining the difference between the wage the person can expect to earn on the market and the person's reservation wage. If the person's (unobservable) attitude toward working is designated as Q, one may estimate the function:

$$\text{(A6)} \qquad Q = \mathbf{X}\,\delta + r$$

where r is a disturbance term that captures the effect of unobserved variables on the person's attitude toward working. Defining a dummy variable q equalling 1 if the person is in the labor force, 0 otherwise, and a threshold value of Q which will be called B, the estimate of the probability that the person will work is based on the model:

$$\text{(A7)} \qquad q = \begin{cases} 1 \text{ if } r > B - \mathbf{X}\,\delta \\ 0 \text{ otherwise} \end{cases}$$

Logit will give an estimate of $(B - \mathbf{X}\,\delta)$, standardized by the standard deviation of r and with B set equal to 0. Denoting this standardized estimate by K, one can estimate what is referred to as the inverse Mills ratio,

$$\text{(A8)} \qquad \hat{\lambda} = f(K)/[1 - F(K)]$$

where f(*) and F(*) are the probability density function and cumulative density function respectively of the logistic distribution.

Then, using observations for workers only, the wage equation is estimated:

$$\text{(A9)} \qquad W = \psi_0 + Z\,\psi + \sigma\,\hat{\lambda} + u$$

where W is observed yearly earnings, **Z** is a vector of personal characteristics such as education, which determine the amount of money a person can expect to make, and u is a mean-zero disturbance term. The presence of the inverse Mills Ratio, $\hat{\lambda}$, in (A9) removes the sample selection bias referred to before. Its coefficient, σ, can be interpreted as the covariance between the decision to enter the labor force and the size of the wage the individual could expect to earn in the labor market. Now an imputed opportunity wage $\underline{W}$ can be assigned, using the other parameters estimated in (A9):

$$\text{(A10)} \qquad \underline{W} = \hat{\psi}_0 + \hat{\psi} Z$$

This value of $\underline{W}$ can be computed for all observations in the dataset, workers and nonworkers alike, since the vector **Z** is observed for all members of the population. It can be plugged into equation (A1), thus solving the problem of a missing wage variable in an econometrically palatable way.

The value of this imputed wage information is even greater for present purposes than it is for the usual labor supply study. Much of the current (and recurrent) controversy over teacher pay proposals centers on the question of teacher quality. A person's imputed wage is a measure of his/her "quality" as determined by the marketplace. One might make an argument for the proposition that education will improve if the classrooms are managed by people who could be making at least as good a living in the business world. And, conversely, a person who could be making more money outside the schools will only stay in the schools if he/she especially likes (and therefore is likely to be especially good at) teaching.

Once the parameters of (A1) have been estimated, one can get estimates for the probability that any person will be a teacher, given the characteristics of the person and of the labor market that were included in Equation (A1). These estimated probabilities can be computed as follows:

$$\text{(A11)} \qquad P(\text{Teach}) = 1 - F\{(A-J)/s\} = 1 / \{1 + \exp[(A-J)/s]\}$$

Note that the relationships between the variables and the estimated probabilities will be nonlinear. That is, the effect of a change in the student/teacher ratio on the probability that a person will teach will depend not only on the previous value of the student/teacher ratio, but also on the person's opportunity wage, race, wealth, and all of the other variables in Equation (A1).

The beauty of this method lies in its extreme adaptability to whatever purpose the policy maker may have in mind. Once in place, the model can be used by the policy maker to predict the effect of a wide range of policy options, as well as to suggest the best path to a policy goal.

APPENDIX B

ESTIMATION OF THE PROBABILITY OF WORKING

The first two steps of the estimation procedure were designed to estimate the parameters of Equation A9. The process of predicting a person's value in the labor market begins with predicting the likelihood that he/she will decide to participate in the labor market at all.

To estimate the likelihood that a person will join the labor force (Equation A6), the entire Current Population Survey (CPS) dataset was used. The Logit estimation package used was the SAS Logistical Regression package (LOGIST). The dependent variable q was set equal to 1 if the respondent worked one or more weeks in 1982 or was involuntarily unemployed. The X variables chosen reflect the standard neoclassical labor supply model. In that model, the income/leisure budget constraint becomes steeper as the individual's market wage increases due to experience and/or education. This steepening of the budget constraint makes the individual prefer to work more hours and increases the likelihood that he/she will work at all. In addition, the budget constraint shifts upward in a parallel manner as unearned income increases, making labor force participation less likely. Finally, anything that increases the value of the person's "leisure" time, such as the arrival of a child or household duties, will raise the marginal rate of substitution of income for leisure (i.e., steepen the indifference curves) and also make labor force participation less likely.

The results of the estimation were as predicted by the neoclassical model. They are summarized in Table B1. Factors that the estimation showed as tending to make a person more likely to work include being older (although the importance of age diminishes as a person becomes older), being male, and being better-educated. Factors diminishing one's likelihood of working include being a woman with a young child, having a lot of nonlabor income, and being a city dweller. Factors whose effects were not statistically significantly different from zero included race, the number of children under 18 years old, marriage, and being a man with a young child.

TABLE B1

LOGISTIC REGRESSION PROCEDURE

DEPENDENT VARIABLE: ILF, WHICH EQUALS 1 IF PERSON IS IN THE LABOR FORCE.

MAX ABSOLUTE DERIVATIVE=0.3307D-07.   -2 LOG L= 878.62

MODEL CHI-SQUARE= 723.70 WITH 15 D.F. (-2 LOG L.R.) P=0.0 .

VARIABLE	BETA	STD. ERROR	CHI-SQUARE	P
INTERCEP	-1.00811180	0.60836789	2.75	0.10
AGE	0.03393948	0.01655737	4.20	0.02
AGESQR	-0.00107681	0.00032326	10.50	0.00
SEX	0.75375887	0.10978842	47.06	0.00
EDATTD	0.09891951	0.06407601	2.38	0.12
EDSQR	-0.00015708	0.00281561	0.00	0.96
FEMDC	-0.68161704	0.38507439	3.13	0.08
TOTINCOT	-0.00003273	0.00001777	3.39	0.07
TOTFAMOT	-0.00001194	0.00001157	1.06	0.30
SPOUSINC	-0.00000430	0.00000402	1.14	0.28
URBAN	-0.15623209	0.10071934	2.40	0.12
RACE	-0.14945056	0.13021000	1.30	0.25
CLDUN18	-0.01730781	0.05600852	0.10	0.70
MARRIED	-0.06312631	0.12026095	0.28	0.60
DCNEED	0.24996446	0.35330379	0.50	0.48

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