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ABSTRACT

A Markov chain is used to construct a simulation model of the educator labor market in Oregon. The variables crucial to this study, drawn from the University of Southern California faculty planning model, include factors such as appointment rate: age: probability of attaining promotion: retirement, resignation and mortality rates: length of probationary period: size of faculty: and faculty salaries. A two-state faculty flow model that represents both tenured and nontenured faculty is utilized and applied to elementary and secondary educators. In considering this group of educators, the importance of rank and tenure is reduced and that of turnover greatly increased. The simulation model makes possible projections on the future composition of a faculty according to demographic and experiential variables. Empirical transition rates have been determined for the state as a whole and for selected districts. From this data, a variety of sets of personnel policies will be simulated. (Author/WD)

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SIMULATION OF TEACHER DEMAND, DEMOGRAPHICS, AND MOBILITY: A PRELIMINARY REPORT

by

William H. Baugh and Joe A. Stone

Simulation of Teacher Demand, Demographics, and Mobility:

A Preliminary Report

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1. Theoretical Considerations

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A Markov chain is a mathematical model used to describe a process in which individuals move through a set of possible states or conditions in a set of steps. It is one of the larger class of stochastic models, so called because whether any specific individual will make a state transition at a particular point in time is known only probabilisitcally. In using such models we therefore divide individuals into classes according to the particular state they are occupying. We also divide the "world" into a set of possible states which are mutually exclusive and exhaustive. When there is only a finite number of possible states, the model is said to be <u>finite</u>. Moreover, since the important things to know about any individual in such a model are (1) what state he or she is occupying at any given moment and (2) what the probability is that the individual will move to each other possible state in the next time period, the system described by such a model is said to be state-determined. (See Kemeny and Snell, 1960, for a more complete discussion of finite stochastic models.)

The application of such models to labor market analysis is conceptually straightforward. A successful educator, for example, will move through a series of clearly defined states in normal career development. Those states will include education, hiring, tenure, advancement, and eventual retirement, and may well include a number of relocations. A less successful educator may also spend some time in other states, such as fired, on layoff, retraining, or midcareer change. Appropriate data, such as that we have obtained from the Current Population Survey (hereinafter CPS) and the Oregon Department of Education Annual Report on Certificated Personnel (hereinafter OCP), will allow the estimation of empirical transition rates, as well as the determinants of those rates, simply by following a number of individuals over time or between two time points. The robustness of the model may then be tested by simulating the development of selected empirical cases over time.

The theoretical foundations of such simulation models in Markov chains are considered in detail in our paper "Analytic Methods and Models for the Educator Labor Market," previously submitted. For present purposes, it suffices to note that we expect that the educator labor market can be modelled as a finite, regular, ergodic Markov chain. Whether that chain is of higher than first order, and the length of time or set of conditions under which it will be stationary, must be determined empirically. The estimation of the transition parameters is discussed in some detail in Sections 3 and 4, below. In general, we need to know the variables that are crucial in the market (demand, supply, salary structures, et cetera), some of which are specific to individuals, locations, or schools, and the behavioral attributes (age, training, career goals, et cetera) with which they interact. Once the parameters have been estimated, the Markov chain model can then be utilized for simulation analyses. Such analyses allow us to (1) test the robustness of the models with respect to changes in the values of important parameters; (2) improve the specification of the model to yield more accurate predictions; (3) forecast trends to be expected under selected policies; and (4) derive policy recommendations on the basis of the simulation results. This methodology enables us to analyze the interactions of the relevant variables and policy alternatives simultaneously. Consequently, we can develop sets of personnel policies appropriate to meet different educational and administrative goals in institutions or districts with particular sets of characteristics or problems.

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2. Development of Simulation Models

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Over the decade of the 1970s scholarly interest in educational personnel planning rose considerably. Much of that interest was reflected in studies of changes in tenure, retirement, and affirmative action policies in higher education. While many of those studies utilized simulation models, little attention was paid to applying them to K-12 educators. Robert M. Oliver (1969) used a set of linear models to define graphically the regions feasible to future appointment and retirement policies which corresponded to desired parameters for percent tenured, promotions, and rank distributions from University of California at Berkeley data for 1955-1967. Oliver directed attention primarily to tradeoffs in equilibrium practices, rather than to short-term effects. David Hopkins (1972) examined both long-term and short-term effects. Both the Oliver and Hopkins studies utilize a two-state faculty flow model in which one state represents tenured faculty and the other state represents non-tenured faculty. They then use as crucial variables the rates of new appointments, resignations, and mortality for each state, plus the number in each state, promotion rate of nontenured faculty, and retirement rate of tenured faculty. While all these rates except the tenure resignation rate are largely determined by institutional personnel policies, specifying any four of the eight variables determines the others in a time of steady-state personnel practices.

While Hopkins treated the tenure ratio as exogenous to the model, others have recommended that a fixed tenure quota be set and that the other rates should depend on that quota. William Baumer (1973) of SUNY at Buffalo, devised a mathematical model to test the consequences of various tenure ratios. Taking a different approach, David Dill (1974) constructed a "tenure prospect ratio" and used a two-state faculty flow model to illustrate the impacts of that ratio and of tenure quotas on faculty demographics. As experience with the use of such simulation models grew through the 1970s, the complexity and realism of the models also grew. The Institute for Educational Development's <u>Twelve College Faculty Appointment and Development Study</u> (1973), for example, included examination of the effects of selected hiring, promotion, tenure, and retirement practices on such outputs as costs of faculty salaries, percentage tenured, and rank distribution.

Among the various faculty flow simulation models based on Markov chains, the USC Faculty Planning Model developed at the University of Southern California seems to capture the variables crucial to our study in the most simple and straightforward manner. As orginally developed, that model incorporates the following variables:

1. New appointment rate to non-tenure
2. Average age of new appointments to non-tenure
3. New appointment rate to tenure
4. Age of new appointments to tenure
5. Annual probability of attaining tenure for non-tenured
6. Annual probability of promotion from one rank to the next
7. Retirement rate of tenured faculty
8. Resignation and mortality rate of non-tenured
9. Resignation and mortality rate of tenured
10. Average probationary period of non-tenured
11. Size of faculty
12. Proporation of faculty tenured
13. Age and rank distribution of the faculty
14. Faculty salaries

In applying this model to K-12 educators, rank and tenure are greatly reduced in importance, while causes of turnover are greatly increased. Both sets of changes can be accomplished readily through appropriate recodings of the parameters.

Application of the U.S.C. model is discussed in the following sections.

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3. Methodology

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Adaptability to simulation is one of the significant advantages of finite stochastic models; they are discrete time models and the number of possible values of the variables (i.e., the number of states) is limited. The basic structure of the USC Faculty Planning Model is a Markov chain, and its structure is sufficiently complete and flexible to meet our local simulation needs on this project. Having estimated the the empirical transition probabilities, we can determine the order and character of the transition chain and go on to use simulation to perform a variety of sensitivity analyses. Average rates (or transition probabilities) of promotions, new entries and reentries into teaching, retirements, layoffs (or dismissals), and quits (to leave teaching or to accept another job) can be obtained directly from the DCP data file and, to a more limited extent, from the CPS file of national data. Details of both data sets have been set out in our previous papers and progress reports. Given those transition rates and a initial composition of a faculty, we can project the future composition of that faculty according to demographic and experience variables, under a variety of different sets of personnel policies determining the crucial transition rates. Beyond this, in our work on "Mobility and Wage Equilibration in the Educator Labor Market," separately submitted, we are able to use the same data bases to examine some of the determinants of the transition rates, e.g., the impact of wage differentials on the probability of quitting teaching. We thus combine simulation with the regression-based studies to effect a more complete study of the impact of sets of personnel policies.

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4. Preparatory and Future Work

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During the past quarter, an SAS (Statistical Analysis System) data file was prepared for the last eight years of the OCP data, school years 1971-72 through 1978-79. For those years the data set is complete for all districts in Oregon, is relatively free of coding errors, and has a missing data rate of less than one percent for each variable. From the SAS data file an extensive series of crosstabulations of mobility variables was run to determine the empirical transition rates for teachers entering and leaving teaching for the state as a whole and for selected districts. We had previously selected the following districts for special scrutiny in our future work on "Effective Personnel Policy Under Enrollment Duress:"

Bend

Eugene

Portland

Redmond

This set of districts exhibits enrollment trends spanning a wide range of possibilities, with consequent impacts on the size and composition of faculties. Portland has a fixed service area that is highly urbanized, and is experiencing an aging population and limited in-migration. In recent years an early retirement program was initiated in partial response to the need to shrink faculties. Eugene has experienced a slight downturn in enrollments following a period of rapid population growth. The Bend-Redmond area, in contrast, experienced extremely rapid growth in enrollments because of rapid development, but that trend has been brought into question during 1980 because of the severe economic recession experienced in the timber industry. The empirical transition rates obtained for the state are summarized in Table 1, below. Comparable rates have been obtained for the specific districts and are currently being checked for internal consistency. Given initial demographic compositions of the faculties, a variety of sets of personnel policies will be simulated for the state at large and for the four selected districts. Among other policies to be simulated are the three scenarios discussed in our paper on "Trends in the Educator Labor Market," separately submitted. The USC Faculty Planning Model program is also being adjusted for the University of Oregon's recent conversion from a PDP-11 to a DEC-1091 computer. By prior agreement, the simulation work is to be completed during the first quarter of FY1981.

Table 1: Transitions of Oregon Classroom Teachers

School Year	New Arrivals	Retire-ments	Leaves	Departures Other	Total
1971-72		377	362	2305	3044
1972-73	2870	372	395	2432	3199
1973-74	2858	380	329	2469	3178
1974-75	3092	344	323	2671	3338
1975-76	2511	299	391	2175	2865
1976-77	2491	449	436	2048	2933
1977-78	2868	384	571	2526	3481
1978-79	2810	300	895	2533	3728

Source: Data from annual census of certificated personnel by Oregon State Department of Education (OCP data set), coded for classroom teaching occupations.

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