Applied Microbiology. The authors think these cards will significantly increase the student's ability to correctly employ the basic techniques of microbiological analysis. In addition, the authors would like to see the materials developed in this project made available to other faculty members at Kansas State University, as well as to other institutions nationally and internationally. Continual improvement on this project is recommended so that all the initial goals can be achieved.

An Analysis

Faculty Movement and Composition Within a Land Grant Institution

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and
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Abstract

Land grant institutions are faced with the difficult tasks of maintaining quality teaching, research, and extension programs under declining student enrollments and reduced financial support from federal a.ıd state governments. A major factor in the quality, reputation, and flexibility of different colleges within a land grant institution is the composition of the college's faculty. For this paper a Markov Chain Faculty Flow Model was developed to project future faculty composition for each college given a specific faculty hiring policy. When the Markov Chain Faculty Flow Model is combined with the university budget and curriculum direction of the university administration, administration and faculty of the College of Agriculture can estimate the potential effects as to teaching loads, course offerings, and research fund support within the college.

Introduction

Land grant institutions like many other university systems are faced with adjusting their priorities and hiring practices as they move from the enrollment expansions of the 1960's to lower enrollment numbers and retrenchment of the 80's. Student enrollment is projected to decline in the 80's because the college cohort age group has declined by 15 to 20 percent. In addition, enrollment patterns by students have changed in many universities. The traditional liberal arts education major has changed to a curricula orientation toward professional careers (such as agriculture, business, and engineering). This shift in curricula preferences has also changed hiring practices of universities. In some liberal arts areas the demand for new faculty is low, while in some professional curricula disciplines the supply of new faculty members does not meet the demand at current salaries. This has increased salary differences across disciplines and has contributed to the phenomenon of salary compression[1] in many of the professional curricula areas.

Also, during this period, revenues from tuition, federal and state sources, and endowments have not kept pace with the increased costs of operating a land grant institution. Administrators and faculty members cognizant of these budgetary problems have enacted plans to reallocate resources. Central to resource allocation in a university system is the problem of faculty and its composition. Faculty related institutional costs represent at least 50 percent of an institution's expense (Wilson, 1979), and the tenure and rank composition of a university's faculty greatly effects the flexibility of a program, or lack of it, to respond to changes in demands and costs.

Many faculty models and studies have been done at non-land grant institutions which investigated the effects of changes in tenure-ratios, increases or decreases in retirement age for faculty members and other faculty management scenarios on the university's faculty composition, and ultimate financial status of the university (Eddy and Morrill, 1975; Franz et al., 1981; Hopkins, 1974; Pickett, 1971). However, these models have not investigated the separate colleges within a university system to detect faculty composition differences between colleges and potential effects of such faculty composition on the flexibility of the university to enact personnel changes.

Professors and instructors in the Agricultural College of a land grant institution need to be aware of the flow of faculty or changes in faculty composition, not only in their own college but other colleges within the land grant university. Because colleges within a university are interrelated primarily through the university budget, changes in faculty flow of a particular college such as the College of Engineering, will affect funding levels and faculty support in the College

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[1]Because of the limited number of new doctorates in many of the professional curricula areas, the salaries offered to the new doctorate usually exceed the salaries of assistant professors, who were hired two or three years prior by the university. Often the salaries offered to the new doctorate approach or exceed salaries of some of the associate professors in the discipline. Because the salary differences between ranks of faculty members in many of the professional curricula areas are quite small, this phenomenon is called salary compression.

of Agriculture. The primary objective, therefore, of this study was to analyze faculty composition and flows of different colleges in a land grant institution using a Markov Chain analysis. A Markov Chain Faculty Flow Model for each college at the University of Nevada, Reno, was developed to detect differences in faculty composition and personnel policies between colleges. Also, by comparing faculty flow models of different colleges, differences in faculty composition between professional curricula and non-professional curricula disciplines were determined.

Procedures

The Markov Chain is an accepted mathematical tool for personnel management and is well suited for academic personnel modeling. A more detailed discussion on the application of Markov Chain analysis for manpower planning is presented in a study by Hopkins (1974).

Markov Chain analysis assumes that any population of individuals or entities can be classified into various groups or "states" and the movement of individuals or entities between states over time can be regarded as a stochastic or probabilistic process. With a given set of states ($S_1, S_2, \ldots, S_N$), it is assumed possible to estimate the probabilities (P_{ij}) of individuals moving from S_i to S_j. The probabilities of movements during a given period can be expressed in a transition matrix P as described below:

$$P = \begin{array}{c} \\ S_1 \\ S_2 \\ \vdots \\ S_n \end{array} \begin{array}{c} \begin{array}{ccc} S_1 & S_2 \cdots & S_n \end{array} \\ \begin{bmatrix} P_{11} & P_{12} \cdots & P_{1n} \\ P_{21} & P_{22} \cdots & P_{2n} \\ \vdots & \vdots \ddots & \vdots \\ P_{n1} & P_{n2} \cdots & P_{nn} \end{bmatrix} \end{array}$$

The states for this paper are the different classifications of faculty and are given below as:

State	Faculty Category
S_1	Lecturer
S_2	Assistant Professor
S_3	Associate Professor
S_4	Full Professor
S_5	No longer employed at the University

From the state classifications, a transition matrix for each college at the University of Nevada, Reno, was developed. From these transition matrices differences in the composition and flow of faculty in the different colleges within a land grant system were estimated.

Estimating the Transition Matrix

To estimate a transition matrix of faculty flow, data are required to describe movements of individuals over time. Faculty members were tracked according to rank using the University of Nevada, Reno, catalogs from 1979 to 1983. Separate transition matrices were derived for the college of Agriculture, College of Business Administration, College of Engineering, and College of Education. For the College of Arts and Sciences, separate transition matrices were derived for Bachelor of Science and Bachelor of Arts curricula oriented programs. Adjunct faculty and administration were not included in the transition matrix development, and any faculty member who left the University was treated as a new faculty member if he returned.

The transition matrix for this paper is assumed to be stationary or that the transition probabilities continue indefinitely into the future. However, this assumption can be relaxed if an alternative faculty personnel policy should be enacted that could alter the transition probability from one state to another.

Using the stationary transition matrix and alternative faculty hiring policies, the effects of such hiring policies on faculty composition and University budget can be estimated. Also, from the transition matrices for each college, composition characteristics of each college's faculty can be derived and suggested changes in hiring practices to alter the current faculty composition of a particular college can be made.

Analysis of Current Faculty Flow and Composition Characteristics

The heart of the Markov Chain process is the transition probability matrix. Table 1 shows the transition probability matrix for each college at the University of Nevada, Reno. Each flow chart shows the probability of movement from one state to another during a single time period. The coefficients in the transition matrix indicate the percentage of faculty members in S_i that will probably be in S_j during the next year. A requirement in the Markov Chain process is that the sum of the coefficients in any row must always be unity if all faculty members are to be accounted. Column S_5 indicates that some faculty members from S_1, S_2, S_3, and S_4 are leaving the University. State S_5 is called an "absorbing state" because faculty members can enter this state but cannot leave.

Coefficients in the transition matrix derive useful information not readily available from other types of models. For example, coefficients of row S_3 in the College of Agriculture (Table 1) indicate that approximately 3.7 percent of the College's associate professors will leave the University during the next year. Of this same group, 90.7 percent of the associate professors in the College of Agriculture will remain as an associate professor during the next year and 5.6 percent of the associate professors will rise to the status of full professor. In comparison, 88.1 percent of full professors in the College of Agriculture will remain as full professors the next year while 11.9 percent will leave the university. As for assistant professors in the College of Agriculture, 90.4 percent will remain as assistant professors while 7.7 percent will be promoted

Table 1. Transition Probability Matrix of Faculty Members for Different Colleges at the University of Nevada-Reno.

	S_1	S_2	S_3	S_4	S_5
College of Agriculture					
S_1	0.800	0.000	0.000	0.000	0.200
S_2		0.904	0.077	0.000	0.019
S_3			0.907	0.056	0.037
S_4				0.881	0.119
S_5					1.000
College of Engineering					
S_1	0.500	0.330	0.000	0.000	0.170
S_2		0.814	0.023	0.000	0.163
S_3			0.810	0.190	0.000
S_4				0.915	0.085
S_5					1.000
College of Business Administration					
S_1	0.444	0.112	0.000	0.000	0.444
S_2		0.737	0.105	0.000	0.158
S_3			0.894	0.053	0.053
S_4				0.939	0.061
S_5					1.000
College of Arts and Sciences Bachelor of Arts Program					
S_1	1.000	0.000	0.000	0.000	0.000
S_2		0.857	0.143	0.000	0.000
S_3			0.882	0.089	0.029
S_4				0.900	0.100
S_5					1.000
College of Arts and Sciences Bachelor of Sciences Program					
S_1	0.874	0.063	0.000	0.000	0.063
S_2		0.750	0.150	0.000	0.100
S_3			0.891	0.082	0.027
S_4				0.927	0.073
S_5					1.000
College of Education					
S_1	0.660	0.000	0.000	0.000	0.340
S_2		0.580	0.170	0.000	0.250
S_3			0.820	0.140	0.040
S_4				0.930	0.070
S_5					1.000

to the associate professor level, and 1.9 percent will leave the University.

Faculty composition in the College of Agriculture can be contrasted to other colleges at the university by comparing transition probability matrices. Administrators in the College of Agriculture can use this information, for example, to estimate the effects on their college's budget, corresponding teaching loads, and faculty support if a new program such as "hi-tech" engineering is promoted by the university's administration with little or no increase in the total university budget. The above presupposes that the university administration, rather than the college, allocates positions to the academic departments.

From Table 1, interesting comparisons and contrasts can be made between the flow of faculty in the College of Agriculture to the College of Engineering and College of Business Administration. Assistant professors in the College of Engineering leave the university at a rate approximately nine times greater than the rates in the College of Agriculture and infinitely higher than assistant professors in the Bachelor of Arts program in the College of Arts and Science. Results in Table 1 suggest that the College of Engineering must replace sixteen percent of its assistant professors each year if the current number of assistant professors in the College of Engineering is to remain constant. As for the College of Business Administration, the probability of an assistant professor leaving the university is high, although not as great as evidenced in the College of Engineering.

In discussions with both Deans of Engineering and of Business Administration, the effects of higher salaries in the private sector for professionals in these fields are a significant factor in assistant professors leaving academia. Also, for engineering, a large number of universities across the nation are emphasizing "hi-tech" education by increasing appropriations and emphasis on their College of Engineering. This has caused increased competition for the few Ph.D graduates and assistant professors in the different areas of engineering. In an article in AAUP Bulletin (1982), differences in demand and supply of doctorates between disciplines are discussed. New Ph.D's and assistant professors in area specialties such as business, computer science, and engineering are in high demand, which increases competion for the services of these professions.

Problems the College of Engineering and College of Business Administration have in retaining assistant professors will have an impact on the College of Agriculture. Given the current emphasis on professional curricula, especially in engineering and business administration, a move by the university's administration to increase the stature of these two colleges may mean a shift in funding. If the university's budget is not increased to finance expansion of the College of Engineering and Business Administration, budget levels of other colleges of the university, including the College of Agriculture, may be decreased. This may result in vacant faculty positions not being filled. Faculty in the College of Agriculture may have teaching loads increased, selected courses eliminated, and funds for agricultural research reduced.

New doctorates in the School of Arts and Sciences under the Bachelor of Arts Program face a different labor market as compared to the labor market faced by educators in the College of Engineering and Business Administration. For faculty members in the Bachelor of Arts Program, a surplus of educators exists as compared to the demand. The imbalance in supply and demand for academic labor in the Bachelor of Arts Program market developed in the 70's. In 1971, the annual meetings of the Modern Language Association was disrupted by graduate students unable to find a single job interview (Cartter, 1976) Also, at the 1971 American historical Association convention, 2300 students pursued 155 listed job openings (Stone, 1972). Because of such labor market imbalance, outside employment opportunities for assistant professors in the Bachelor of Arts Program are limited. This is reflected by the zero transition probability of assistant professors in the Bachelor of Arts Program leaving the University of Nevada, Reno. For the Bachelor of Science Program in the College of Arts and Sciences, approximately ten percent of the assistant professors leave the university each year. This large transition probability is due in part to the high demands for computer science majors and other science program technical professionals by private industry and other educational institutions (Hansen, 1982).

The College of Education had the lowest transition probability value for assistant professors remaining at this faculty level, but the highest of any college of assistant professors leaving the university. An important contributing factor to these assistant professors leaving the university is the current faculty composition in the College of Education. It is heavily proportioned to tenured full professors. Having a large number of tenured full professors restricts the flexibility of the College of Education and may encourage young professors to leave the university to seek employment at institutions where tenure promotion may be more accessable. However, working with a highly tenured faculty during budget retrenchment may call for innovative personnel management techniques, such as allowing greater number of sabbaticals for upgrading the professional skills of the tenured faculty.

Forecasting Faculty Composition Using the Markov Chain Procedure

The Markov Chain process is time dependent; that is, it can project faculty composition given the transition matrix, hiring policies, and initial composition of the faculty. If P is the transition matrix for different faculty positions in the different colleges at the University of Nevada, Reno, X(t) denotes the component faculty position for each college at time period t, and Y(t) is the number of new appointments made to each faculty classification in time period t, then the faculty composition for each college at time period t + 1 is given by the below equation:

$$(2)\ X(t+1) = X(t) \bullet P(t) + Y(t)$$

Equation 2 can be used to derive both long and short term faculty composition. If one assumes the personnel policy objective of the university is to maintain the current number of faculty for each college by hiring only assistant professors to replace vacant faculty positions, the resulting faculty composition for each college after five years is shown in Table 2.

For the College of Engineering, assistant professors after five years will make up more than fifty percent of the total College's faculty. However, from Table 1, the rate at which assistant professors leave the College of Engineering is quite high. Therefore, for the university to meet the projected number of assistant professors in Table 2, the College of Engineering will annually have to hire a large number of assistant professors. It may be wise for the university administration and administration within the College of Engineering to pursue personnel policies which would reduce the flow of assistant professors leaving the university and lower this transition probability.

Table 2. Five Year Projected Faculty Composition for Each College at the University of Nevada, Reno, if Assistant Professors Only Filled Vacant Faculty Positions.

Faculty Category	Current Situation: Faculty Composition (number)	Current Situation: Faculty Proportionate Composition (percent)	Five Year Projection: Faculty Composition (number)	Five Year Projection: Faculty Proportionate Composition (percent)
College of Agriculture				
Assistant Professor	18	28.1	30	46.8
Associate Professor	19	29.7	17	26.6
Full Professor	27	42.2	17	26.6
College of Engineering				
Assistant Professor	11	37.9	16	55.2
Associate Professor	4	13.8	2	6.9
Full Professor	14	48.3	11	37.9
College of Business Administration				
Assistant Professor	5	13.2	10	26.3
Associate Professor	14	36.8	11	28.9
Full Professor	19	50.0	17	44.8
College of Arts & Science-Bachelor of Arts				
Assistant Professor	26	19.7	37	28.0
Associate Professor	54	40.9	47	35.6
Full Professor	52	39.4	48	36.4
College of Arts and Science-Bachelor of Science				
Assistant Professor	6	12.0	12	24.0
Associate Professor	20	40.0	17	34.0
Full Professor	24	48.0	21	42.0
College of Education				
Assistant Professor	2	8.4	6	25.0
Associate Professor	5	20.8	3	12.5
Full Professor	17	70.8	15	62.5

Also, from Table 2 the proportionate composition of assistant professors in the College of Agriculture rose from 28.1 percent to 46.8 percent in five years. The proportionate rise in assistant professor composition is associated with a decline in proportionate faculty composition of full professors from 42.2 percent to 26.6 percent.

Using discipline and faculty salary survey data from the Office of Institutional Research at Oklahoma State University (1982), the effects on total university faculty salaries from the employment practice of hiring only assistant professors to fill vacant faculty positions was estimated. Total university faculty salaries declined from $9,718,900 in the current year to $9,405,660 in the five year projection using the projections in Table 2. Different total university faculty salary estimates would be obtained if different faculty hiring practics are assumed.

For the above example, it was assumed that only assistant professors were hired to fill vacated faculty positions.. This faculty hiring policy has both its advantages and disadvantages. One major disadvantage in hiring only new Ph.D's as assistant professors to fill vacated positions is that they are unproven. It can be assumed that new assistant professors have been exposed to the new procedures, methodologies and theoretical developments in their discipline, but their abilities as a teacher and/or researcher are unknown.

If, however, the university attempts to hire associate professors and/or full professors to fill most of the vacated faculty positions in the college the university will employ persons having proven records as teachers and/or researchers. If the newly hired associate or full professor is recognized by their discipline, the new faculty member immediately adds prestige to the college and university. If the new faculty member is a noted researcher, the university can become a recipient of additional grant monies. However, the major disadvantage in hiring an associate and/or full professor to fill vacant faculty positions is that the salary necessary to attract faculty of this rank may be quite high and could strain the university budget.

As can be seen from Tables 1 and 2, the Markov Chain procedure can be used to forecast the effects on faculty composition and salaries from various employment strategies. If a new department is created or curricula emphasis of the university administration is changed, such as, promotion of "hi-tech" engineering courses, the potential effects to the faculty of the College of Agriculture can be estimated.

A major objective of this paper is to provide a vehicle by which faculty of different colleges at a university can recognize the interrelationships between their college and other colleges on campus. Using the Markov Chain Faculty Flow Model and estimated university budget, changes in faculty composition and number for each college in the university can be forecast for a specific employment policy and university curriculum direction. From such an analysis, administration and faculty in the College of Agriculture are able to estimate the possible effects to themselves and their program if a given university administration policy is enacted.

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Optimal Readiness Testing: Giving Students a Choice

Frank W. Woods

Abstract

Are students better prepared than their teachers to determine whether they are personally ready to take an examination at any given time? In two courses, for four years, students were given the option of determining whether they wished to take the first two of three tests which were administered each term. The evidence indicates that they preferred to be given a choice rather than be required to take all three tests.

Introduction and Objectives

During and following a unit of work, students are tested to find out how much information they have assimilated and are able to use. How frequently should tests be administered to make these determinations, and who should determine their rate of frequency? Options for the instructor seem to be without limit, varying from short, daily quizzes to a single examination given at the end of the term. However, the ability of even excellent students, who may be taking as many as four to six courses, to bring all loose ends

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