DOCUMENT RESUME

ED 174 091 HE 011 432

AUTHOR	Kutina, Kenneth L.; Bruss, Edward A.
TITLE	Faculty Flow in a Medical School: A Policy Simulator. AIR Forum 1979 Paper.
SPONS AGENCY	Association of American Medical Colleges, Washington, D. C.; National Library of Medicine (DHEW), Bethesda, Md.
PUB DATE	May 79
NOTE	24p.; Paper presented at the Annual Forum of the Association for Institutional Research (19th, San Diego, California, May 13-17, 1979)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*College Faculty; *Computer Oriented Programs; Data Analysis; *Faculty Promotion; Higher Education; *Medical Schools; *Models; *Personnel Data; Personnel Policy; Simulation; *Tenure
IDENTIFIERS	*AIR Forum 1979; Case Western Reserve University OH

ABSTRACT

A computer-based simulation model is described that can be used in an interactive mode to analyze the effects of alternative hiring, promotion, tenure-granting, retirement, and salary policies on faculty size, distribution, and aggregate salary expense. The model was designed to be adequately flexible and comprehensive to incorporate the array of faculty appointment and tenure types found in medical schools throughout the United States. It has been implemented and tested on historical faculty data from the Case Western Reserve University School of Medicine. The Monte Carlo method of simulation was chosen as the most effective technology. The present model is called the "Tenure and Promotion Policy Simulator" and is programmed in the BASIC language. The entry, promotion, tenure status, and departure of full-time faculty members of the School of Medicine was traced from 1944-45 through 1977-78, totaling over 1,850 individuals. A computer data file was then constructed containing encoded biographical and appointment history information. Six data aggregation and synthesis computer programs were written to display the data in forms appropriate for analysis of the interrelationships of each variable on others. Statistical tests were run to determine the independent variables that have a significant relationship with the probability of a faculty member receiving a promotion, tenure, and other actions. Validation of the model was also undertaken. (SW)

THE ASSOCIATION FOR INSTITUTIONAL RESEARCH

ED174091

HE 011 132

This paper was presented at the Nineteenth Annual Forum of the Association for Institutional Research held at the Town and Country Inn in San Diego, California, May 13-17, 1979. This paper was reviewed by the AIR Forum Publications Committee and was judged to be of high quality and of interest to others concerned with the research of higher education. It has therefore been selected to be included in the ERIC collection of Forum papers.

Mary Corcoran
University of Minnesota
(Editor, AIR Forum Publications)

FACULTY FLOW IN A MEDICAL SCHOOL - A POLICY SIMULATOR

KENNETH L. KUTINA, Ph.D.

Associate Dean for Planning and Administration

Case Western Reserve University, School of Medicine

2119 Abington Road, Cleveland, Ohio 44106 U.S.A.

Telephone (216) 368-2796

EDWARD A. BRUSS, M.S.

Assistant Director, Planning Office

Case Western Reserve University, School of Medicine

2119 Abington Road, Cleveland, Ohio 44106 U.S.A.

Telephone (216) 368-2796

May 1979

Faculty Flow in a Medical School - A Policy Simulator

This paper describes a computer-based simulation model which can be used in an interactive mode to analyze the effects of alternative hiring, promotion, tenure granting, retirement and salary policies on faculty size, distribution, and aggregate salary expense. The model was designed to be adequately flexible and comprehensive to incorporate the array of faculty appointment and tenure types found in medical schools throughout the United States. It has been implemented and tested on data from the Case Western Reserve University School of Medicine. This project was conducted under subcontract from the Association of American Medical Colleges and funded in part by the National Library of Medicine.

Although the leveling and even shrinkage of enrollments which has characterized most of higher education in this country has not yet impacted on the system of physician education, a stabilization and perhaps even a gradual reduction of medical school class sizes and faculty numbers seems a likely possibility. Secretary of Health, Education and Welfare, Joseph A. Califano, in an address at the annual meeting of the Association of American Medical Colleges (AAMC) in October 1978, pointed out that the United States may soon be facing an oversupply of physicians, and stated that "the most difficult challenge in the next decade will be to stop the growth (in production of physicians) that was started by government health programs of the 1960's." He pointed out that these programs, by creating new teaching facilities, boosting enrollments and expanding faculties, resulted in a doubling of the number of medical school graduates - from 8,000 in 1963 to 15,000 in 1978. "This looming problem of physician oversupply is a problem of having succeeded all too well: having set out to educate enough physicians, we now face the possibility that we are educating too many," Mr. Califano said. Shifting governmental positions, exemplified by Mr. Califano's observations, will probably lead to a reduction or at least an end to the growth in governmental support of medical schools and thereby in program size and faculty numbers.

The possibility of little further growth or even reduction in faculty size and external funding in medical schools in the near future is raising serious concern among many leaders in the field of medical education as to how to plan for and deal effectively with these changes, especially in regard to the proportion of faculties which are tenured. Legitimate questions can be raised as to whether existing promotion and tenure granting policies are leading to staffing situations in which there will be inadequate flexibility to adjust faculty strength in accordance with teaching, research, and clinical requirements, and adequate faculty turnover to assure vigorous development of programs.

This project, which involved extensive analysis of historical faculty data at Case Western Reserve University (CWRU) School of Medicine and the development of a faculty flow simulation model, was aimed at providing schools with a flexible, generally applicable tool for analysis of alternate promotion, tenure, hiring and retirement policies.

Literature Review

Freeman and Rossmeier (1973) have reported that today's university faculties as a whole are higher ranking, with a higher proportion tenured, and with a higher proportion eligible for tenure than faculties of 20 years ago. They indicate that while numbers of faculty are generally looked at to assess the institution's academic tenure health, a better indicator would be the dollars tied to tenured faculty. Similarly, Bloomfield (1975) has developed a "committed resources index" as an indicator of how many dollars are tied up in a tenure system. Moreover, Bolte, Thomas, and Coleman (1977) argue that an institution's promotion policy may have an even greater effect than its tenure policy in assessing institutional salary commitments. Pointing out that the distribution of faculty among rank will significantly impact on the funds required for faculty salaries, they conclude that promotion systems must be flexible enough to allow for outstanding faculty to advance, while stringent enough so that an institution does not become top heavy with higher salaried senior faculty. In the only article found on the tenure issue as applied specifically to medical schools, Spellman and Meiklejohn (1977) contend that continuing modification and experimentation with tenure systems is necessary for effective educational administration. The fundamental question is how can universities best retain the benefits of tenure without locking themselves into an inflexible environment? Several models have been developed to address some of these issues.

One of the first such efforts was by Rowe, Wagner, and Weathersby (1970) who applied optimal control theory to the analysis of faculty staffing policies. Hopkins (1974) using the Markov chain technique at Stanford defined 17 faculty states in which faculty can reside at any given point in time. They include seven non-tenure positions, seven tenure positions differentiated by age; and retirement, resignation and death. McLaughlin, Montgomery and Smith (1976) report on a similar Markov application.

A Monte Carlo simulation approach has been applied by both Goveia (1975) and Linnell (1976). Monte Carlo simulation introduces realistic stochastic effects in promotion and retirement occurrences, and as applied by Goveia and Linnell, moves faculty through the system individually as opposed to the cohort approach characterized by the Markov chain method.

Combining both simulation methods, Nicely (1975) treats salary as the key variable in his model i.e. given a fixed availability of faculty salary funds, the only source of monies available for salary raises is the difference in salaries of departing faculty and incoming faculty. By simulating the movement of faculty through and out of the system, this model can determine the amount of monies available to hire new faculty.

None of the models examined allow for the incorporation of the unique characteristics of a medical school environment, and most tend to focus on specific key variables in the faculty flow process. For this reason the authors felt a new model development effort was warranted to yield a more comprehensive and adaptable tool for policy planning and analysis. A primary goal of the project was to build a model that was adaptable and transferable not only to medical schools but to other university components as well. The model is structured to allow for a variety of funding sources and faculty appointment types. It is built with dual sets of tenure, promotion, resignation, growth and hiring policies to simulate the diversity exhibited between the clinical and non-clinical departments.

Model Design and Operation

The Monte Carlo method of simulation was chosen as the most effective technology for this particular application because it allows for maximum flexibility and ease in adjusting key policy parameters and it best represents the stochastic nature of the system. Direct simulation of a probabilistic problem via Monte Carlo is simple conceptually, but allows the analyst to incorporate particular details of the system being modeled that are beyond the reach of any general theoretical mathematical model; Hammersley and Handscomb (1964) and Naylor, Balintfy, Burdick and Chu (1966). The model described in this paper is called the Tenure and Promotion Policy Simulator (TPPS) and is programmed in the BASIC language.

The core of TPPS is a logic set which processes one faculty member at a time. An individual is represented by a line of encoded data which is read by the model from a data file containing each person's status as of the end of the previous year. The model determines whether each individual gets promoted, is awarded tenure, resigns, shifts appointment type, etc., by comparing a uniquely generated random number with the probability of occurrence of each of those events. The individual's data line is then updated based on his new status and he is written onto an output file. Every individual on the input file is thus processed, new faculty are "hired" to replace losses or provide growth, and they too are written onto the output file. When every individual from the input file has been processed and new hiring, if any, is complete, one calendar year has transpired in simulated time. To counterbalance the possibility of a model run being skewed because of the particular series of random numbers it draws, it automatically performs a series of complete iterations of the simulation and reports the averages of these multiple passes.

Figure 1 graphically displays the overall flow, inputs and outputs of the model. All data requirements of TPPS are either maintained in external data files, or are computer prompted. The model is designed in this fashion so that the user does not have to alter any aspect of the internal model structure to simulate his own institution or to analyze various policy alternatives.

Figure 2 shows the output generated by TPPS. Of special interest is the column headed "Range". One of the features of Monte Carlo is that the user can get some feel for the precision of the results from the variability observed from iteration to iteration in the simulation. TPPS automatically calculates the standard deviations of the numbers of faculty and salary expense by rank and displays in the "Range" column the 95% confidence interval based on the Student's t distribution. The more iterations run, the narrower the ranges, and hence the more precise the model's estimates are. For a school with a relatively large faculty (over 500) five to ten iterations should yield fairly narrow ranges. For much smaller schools, over 20 iterations may be necessary.

It should also be noted from the output report that the model allows the user to specify up to eight different appointment types for faculty. These are designed to enable the user to simulate the various contractual, tenure and financial arrangements utilized in medical schools in the United States. For example, one can stipulate appointment categories leading to tenure, not leading to tenure, totally or partially funded from various non-university sources, tenure with full, partial or no salary guarantee, and so on.

TPPS is designed to be run in an interactive mode on a time-shared computer. As such it asks the user to enter a number of factors at the start

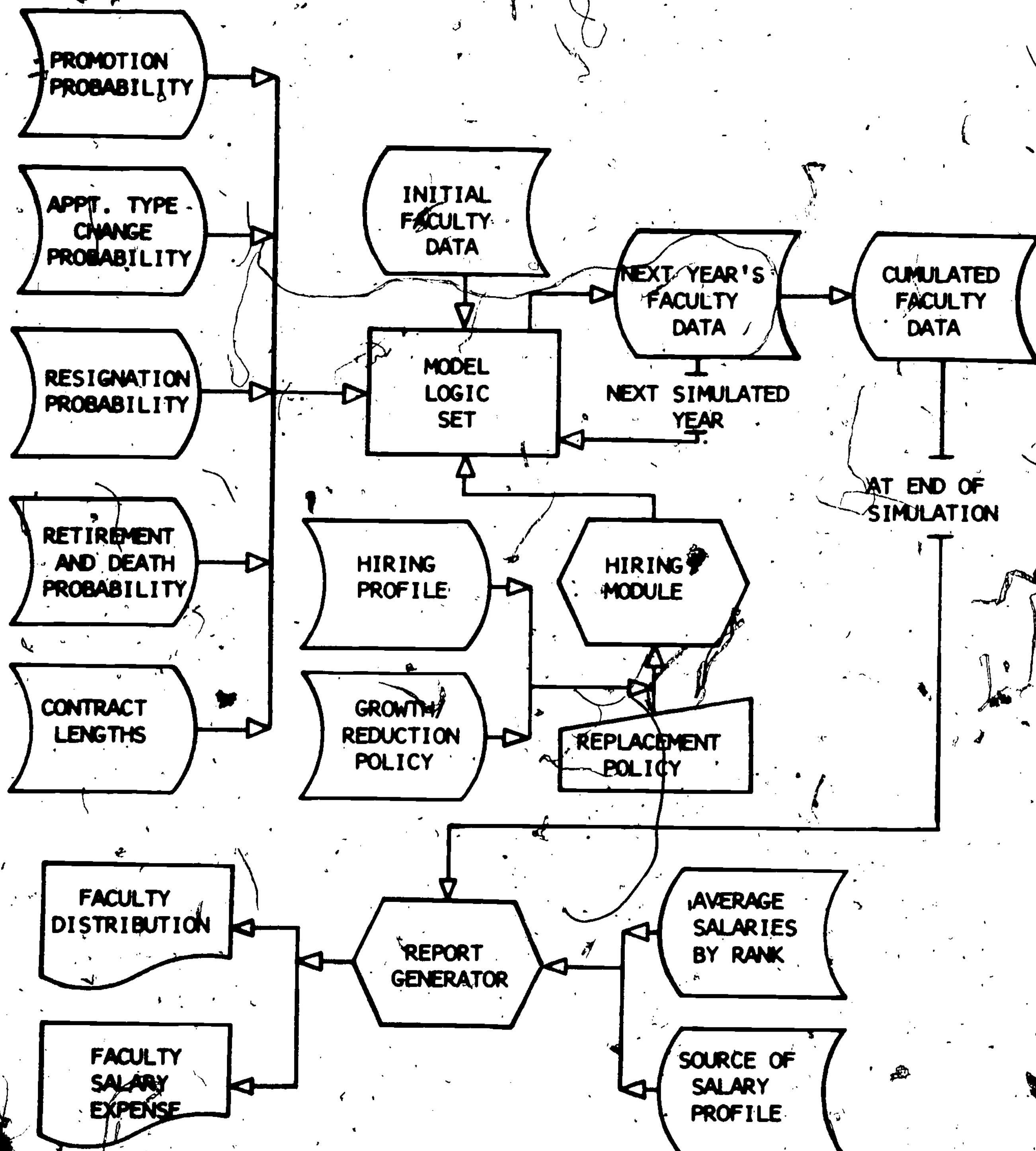

FIGURE 1: Simulation Model Structure

TENURE AND PROMOTION POLICY SIMULATION

RUN DATE TUE 02/27/79/79

YEARS SIMULATED = 10
ITERATIONS PER YEAR = 4

NOTE: 95% CONFIDENCE INTERVAL IS THE VALUE SHOWN + OR - THE NUMBER IN PARENTHESIS

SIMULATED FACULTY DISTRIBUTION

FACULTY DISTRIBUTION AT THE END OF THE BASE YEAR 1977

RANK	NO.	RANGE	AVE AGE	NUMBER BY APPOINTMENT TYPE 1	2	3	4	5	6	7	8	% TEN
FULL PROF.	119	(0)	55	107	0	0	5	0	7	0	0	89.9
ASSOCIATE	129	(0)	47	77	0	0	47	0	5	0	0	59.7
ASSISTANT	373	(0)	40	12	0	0	308	0	53	0	0	3.2
INSTRUCTOR	135	(0)	38	0	0	0	0	0	0	0	135	0.0
TOTAL	756	(0)	43	196	0	0	360	0	65	0	135	25.9

OF FACULTY WHO ENTERED = 0
OF FACULTY WHO LEFT = 0 OF WHICH 0 DIED 0 RETIRED
0 RESIGNED AND 0 WERE TERMINATED

SIMULATED SALARY DISTRIBUTION
($ IN THOUSANDS)

FACULTY SALARY EXPENSE RATE AT END OF THE BASE YEAR 1977

RANK	TOTAL $	RANGE	SALARY SOURCES SCH	SPON	SERV	TENURED $ GUARANTEED	NON-TENURED DOLLARS	% TENURED $ TO TOTAL SAL
FULL PROF.	3553	(0)	1098	391	2064	3188	364	89.7
ASSOCIATE	3249	(0)	852	389	2008	1863	1385	57.4
ASSISTANT	6958	(0)	1126	972	4859	227	6730	3.3
INSTRUCTOR	1802	(0)	122	214	1466	0	1802	0.0
TOTAL	15562	(0)	3198	1966	10397	5278	10281	33.9

FIGURE 2. Sample of TPPS Output Report

of each run. Some of these specify the operational characteristics of the simulation ("run specifications") and others are key policy parameters likely to be frequently altered ("choice variables"). A simulation can also be manipulated to represent specific institutional policies or external influences by altering the various probabilities or data sets which it reads from on-line files and uses in its internal logic as it processes each individual. These variables are called "sensitive parameters". Table 1 lists the important variables of each type which the user can manipulate.

The model and its input data files require about 60,000 characters of file storage. During a simulation run it temporarily requires an additional 100,000 to 200,000 characters of storage depending on the number of years and iterations selected. An average size simulation run (700 faculty, 10 years, 6 iterations) costs about $20 in computer time on a Honeywell 430 time-shared computer.

Data Collection and Analysis

Raw data collection consisted of chronologically tracking the entry, promotion, tenure status, and departure of every full-time faculty member of the CWRU School of Medicine from 1944/45 through 1977/78, a total of over 1850 individuals. From this "tracking" information, a computer data file was constructed containing encoded biographical and appointment history information on each faculty member. Six data aggregation and synthesis computer programs were then written to display the data in forms appropriate for analysis of the inter-relationships of each variable upon others. Analysis of variance, regression and chi square statistical tests were utilized to determine those independent variables (such as age, rank, organizational unit) which have a significant relationship with the probability of a faculty member receiving

TABLE 1. User Manipulative Variables

Run Specifications:

1. Number of years to be simulated
2. Number of iterations
3. Reports for each year, or last year only
4. Starting year of the simulation

Choice Variables:

1. Percentage of faculty leaving who are to be replaced
2. Salary inflation rate
3. Pre-tenure period
4. Years of service within institution below which faculty can be terminated immediately

Sensitive Parameters:

1. Promotion probabilities
2. Tenure probabilities
3. Resignation probabilities
4. Retirement probabilities
5. Death probabilities
6. Probabilities of shifting from one appointment type to another
7. Probabilities of hiring various ranks when a new hire is made
8. Ages of new hires
9. If a reduction program is in effect the proportion of faculty to be terminated
10. If a growth program is in effect the number of new faculty to be added
11. Contract lengths in years

a promotion, tenure, resigning, etc. Those statistically significant functional relationships, which were then incorporated into the model, are shown in Table 2. To minimize model input data requirements, further analyses were run on these functional relationships to determine statistically distinct groupings of the independent variable ranges. These groupings then became the basis for the model input data forms. Figure 3 is an example of one of the input forms resulting from this process. It displays the form utilized to input annual probabilities of promotion to the next higher rank, and shows the groupings statistically selected for the "year in rank" independent variable.

Sensitivity tests were also conducted on subsets of the chronological data to determine the impact of changing system or exogenous factors over the years upon the calculated probabilities. Where appropriate, such as in hiring, the model was structured to accomodate changes in input variables over time.

Validation

A critical last step in any simulation model development and implementation effort is to evaluate the model's ability to emulate reality. This is often done by using the model to simulate past experience where actual outcomes are known, and this method was chosen by the authors. A critical prior step, however, is logic verification, that is to be sure that the model's individual logical elements are functioning as designed. To verify model logic, a variety of small faculty data files on each rank were created. Using these files as the starting faculty data, a series of independent tests were constructed to determine the model's ability to process faculty in accordance with the input probabilities. Once the model logic has been verified, the next validation step was to attempt to simulate a reasonably extensive series of past years.

A starting faculty data file was created with actual profiles at a given point in history -- 1969 was chosen as being adequately far back to provide a

TABLE 2. Functional Relationships[a]

Promotion	= f(rank, years in rank, organizational unit)
Retirement	= f(age)
Death	= f(age)
Resignation	= f(rank, tenure status, age, years in rank, organizational unit)
Termination due to non-tenure	= f(years in tenure track)
Appointment status	= f(rank, years in tenure track, appt. type, organizational unit)
Salary	= f(rank, organizational unit)
Salary sources	= f(appt. type, organizational unit)
Hiring rank	= f(policy, organizational unit)
Hiring age	= f(rank, organizational unit)

a The expression "f( )" means "is a function of".

	NON-CLINICAL DEPARTMENTS				CLINICAL DEPARTMENTS			
	YEAR IN RANK				YEAR IN RANK			
	1	2	3-5	6 & ON	1	2	3-5	6 & ON
ASSOCIATE	0	0	.1	.039	.009	.023	.078	.12
ASSISTANT	0	0	.113	.273	.008	.009	.074	.094
INSTRUCTOR	.28	.124	0	0	.234	.341	.335	.138

FIGURE 3. Input Form for Promotion Probabilities

significant test period. Entering the actual hiring profiles and growth pattern experienced, simulation runs were made which resulted in the comparison graphs shown in Figure 4. The validation tests were also done separately on the clinical and the non-clinical departmental groups to assure maximum precision, and to eliminate the possibility of offsetting errors. The variations from actual occurrence are well within the calculated 95% confidence intervals.

Applications/Conclusions

TPPS can be used to simulate the effects a variety of institutional policies or external influences have both on faculty size and distribution and on faculty salary expense over a period of years. Each, or any combination of data input forms and model variables can be altered in response to a proposed policy change. The user can then run the model under various "scenarios" (i.e. no growth, high growth, high inflation rates, etc.) to determine the future impact of the proposed policies on faculty distribution and salaries at his institution. How will a change in pre-tenure period or a change in tenure granting policies affect the future dollars committed to tenured faculty? How will a sudden growth in clinical faculty affect the overall institutional faculty distribution? How much income from which sources will be required to support that growth? Examples of other policies which TPPS is designed to address, include: (1) varying hiring mixes, (2) varying degrees of stringency or leniency in the awarding of tenure or promotion, (3) varying replacement and/or reduction policies, (4) varying sources of faculty salary support, (5) the introduction of new faculty appointment or contractual arrangements (6) varying retirement ages.

It is a commonly reported phenomenon that many supplementary benefits accrue from a model implementation project to both the staff involved and to

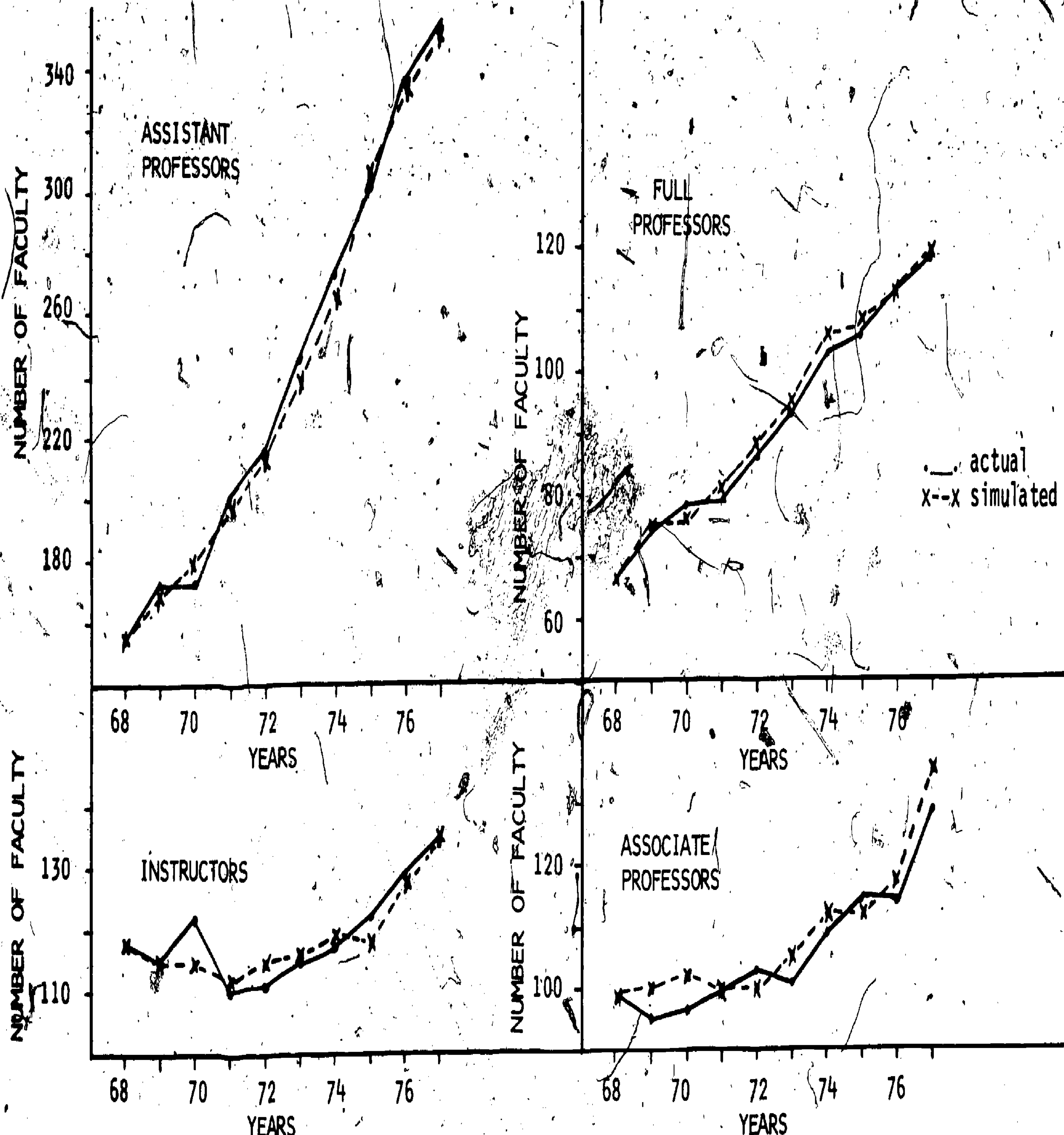

FIGURE 4. Comparison of Simulation With Past Actual Faculty Distribution

the institution which were not part of the original project objectives and were not anticipated. This project was no exception. The primary unforeseen benefit that accrued to the staff at CWRU was a phenomenally sharpened perspective about the utility for analysis purposes of the existing faculty information systems in the Medical School. It was much more difficult to extract relevant data, and the number and variety of sources that had to be unearthed and tapped were much greater than was originally anticipated. Although a project to revise and improve the faculty roster system at the School had been on the staff's agenda of useful projects for some time, it has been moved to <u>first</u> priority.

The project to develop, implement, and report on TPPS required about 16 man-months of effort at CWRU, over an elapsed time of 13 calendar months. It is the authors' estimate that it would take about three man-months of professional effort on the average to fully implement the model at another institution.

Acknowledgments

The authors are pleased to acknowledge the considerable contributions of their colleagues, Ms. Carleen Carver and Dr. Suzanne Polmar, toward the successful completion of this effort. The project was conducted under subcontract from the Association of Americal Medical Colleges and funded in part by the National Library of Medicine.

REFERENCES

Bloomfield, S. A committed resources approach to faculty staffing policies. Proceedings of the 15th Annual Forum, Association for Institutional Research, 1975, 69-72.

Bolte, J., Thomas, M., & Coleman, D. An analysis of philosophies concerning faculty promotion and related implications for the institution. Proceedings of the 16th Annual Forum, Association for Institutional Research, 1976, 205-212.

Freeman, T., & Rossmeier, J. A new look at tenure. Proceedings of the 13th Annual Forum, Association for Institutional Research, 1973, 128-136.

Goveia, J. Tenure and promotion: a comparative simulation. Proceedings of the 15th Annual Forum, Association for Institutional Research, 1975, 87-89.

Hammersley, J., & Handscomb, D. Monte Carlo Methods. London: Methuen and Co., Ltd., 1964.

Hopkins, D. Analysis of faculty appointment, promotion, and retirement policies. Higher Education, 1974, Vol. 3, 397-418.

Linnell, R. Faculty planning - the USC computer simulation model. Journal of Association of Governing Boards of Universities and Colleges, November/December 1976.

McLaughlin, G., Montgomery, J., & Smith, A. Projecting the consequences of tenure awards. Paper presented at the 16th Annual Forum of the Association for Institutional Research, Los Angeles, May 1976.

Naylor, T., Balintfy, J., Burdick, D., & Chu, K. Computer Simulation Techniques. New York: John Wiley and Sons, Inc., 1966.

Nicely, H., Jr. A salary solvency model. Paper presented at the 1975 CAUSE National Conference, Denver, December 1975.

Rowe, S., Wagner, W., & Weathersby, G. A control theory solution to optimal faculty staffing. Paper P-11, Ford Foundation Program for Research in University Administration, University of California, November 1970.

Spellman, M., & Meiklejohn, G. Faculty tenure in American medical schools. Journal of Medical Education, August 1977, Vol. 52, No. 8, 623-632.