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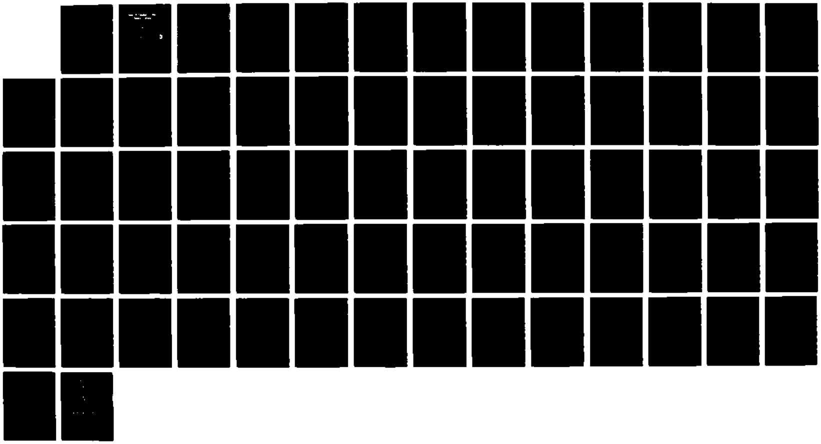

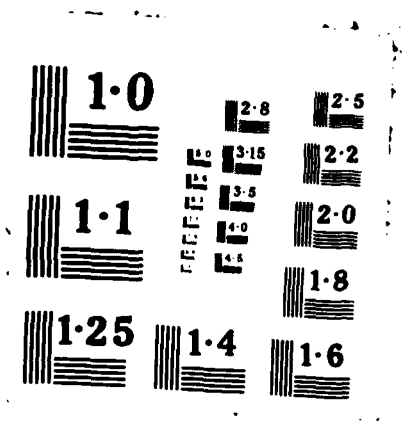
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A MANPOWER MODEL FOR DETERMINING
"C" SCHOOL REQUIREMENTS

by

Pamela A. Jorgensen

December 1987

Thesis Advisor: David R. Whipple
Co-advisor: Paul R. Milch

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This thesis proposes an alternative to the Navy's current procedures for granting quotas for advanced formal training or "C" school. The amount of specialized skill training taught in "C" schools and the costs associated with it have greatly increased over the past years. This thesis proposes an effective method for ensuring that a cost efficient number of personnel are trained in "C" schools. A Markov Chain model is developed utilizing data from the Enlisted Master Record to predict a force inventory of "C" school graduates. The inventory projection shows how "C" school graduates will be distributed among paygrade and use of subspecialty. "C" school planners can use the model to predict changes in the inventory due to changes in the inventory due to changes in "C" school assigments.

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A Manpower Model for Determining "C" School Requirements

by

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ABSTRACT

This thesis proposes an alternative to the Navy's current procedures for granting quotas for advanced formal training or "C" school. The amount of specialized skill training taught in "C" schools and the costs associated with it have greatly increased over the past years. This thesis proposes an effective method for ensuring that a cost efficient number of personnel are trained in "C" schools. A Markov Chain model is developed utilizing data from the Enlisted Master Record to predict a force inventory of "C" school graduates. The inventory projection shows how "C" school graduates will be distributed among paygrade and use of subspecialty. "C"school planners can use the model to predict changes in the inventory due to changes in "C" school assignments.

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I INTRODUCTION

The Navy trains enlisted personnel in a wide variety of skills from relatively simple to highly technical, from broad general ratings to specific task functions. These personnel are then utilized in jobs which range across a wide spectrum of such factors as civilian transferability, undesirable tours, family separation, long sea deployments, etc. Retaining an adequate inventory of trained qualified personnel and controlling their flow to various occupations is challenging, especially as manpower managers need to consider not only the number of enlistees needed in each specialty but also the desired skill and grade structure. To further complicate the personnel manager's task, the manpower personnel system is continually in a state of fluctuation due to the increased sophistication of weapons and support systems. Modernization of the fleet causes annual requirements to change as to total numbers required within each rating and experience mix within the totals. The following study concentrates on improving the Navy's current method of determining advanced skill school accessions required to meet these force goals. Present methods used to calculate inventories of advanced skilled personnel are inadequate to determine the necessary accession rates for these "C" schools.

The Navy of the 1980s spends a great amount of money on training for enlisted personnel. The structure of the Navy is designed to provide the career oriented enlisted person with advanced training as he/she progresses through the ranks. The core of the enlisted career development plan is the

Enlisted Rating Structure. In order to fully comprehend the implications of the Navy's policy towards advanced school accessions, it is necessary to have a good understanding of this career structure.

The Enlisted Rating Structure is comprised of a rate, rating, and possibly a Navy Enlisted Classification (NEC). Rate signifies a person's paygrade (e.g. third class [paygrade of E-4], first class [E-6], Master Chief [E-9]). Upon entering the Naval Service, a sailor is designated E1 and may progress up through experience groups or grade levels to E9 based on time in grade and service, past performance, and skill qualification exams. During his/her initial enlistment he attains the basic job skills and can perform the basic duties, functions and general qualifications associated with a career designation either through on-the-job-training or formal "A" school. The term rating applies to the names assigned to various occupations in the Navy delineated by certain skills, training and experience, e.g.Yeoman (YN), Dispersing Clerk (DK). After he/she is awarded a rating, a sailor can take part in formal "C" school or on-the-job training towards the attainment of an NEC. An NEC is a four digit code which is entered into the individual's service record indicating his/her specific area of expertise. The availability of NEC's further refine the Enlisted Rating Structure by identifying an individual who has acquired special skills which are not required for the entire rating. As an example, a Fire Controllman (FC) who successfully completes Navy Course A-113-0078, the "Close-in weapon system MK-15 Mod 1" "C" school training is awarded an NEC of 1127. An individual can be awarded multiple NEC's. However, the additional NEC's are usually associated with a career progression or technological update. There are more than 1000 NEC's in the Navy. Due to the increasing complexity of fleet equipment, the Navy has required an ever-increasing number of specialized technicians. NEC's were originally intended to associate an individual's skill level with a type of equipment but are now used to place someone with a specific piece of equipment.

A large part of the Navy's training budget, over 600 million dollars annually [Ref. 1], is spent on "C" school training for enlisted personnel. Most "C" schools either award an NEC to the service member upon completion, or lead to another "C" school which will eventually produce an NEC. Other "C" schools provide functional training courses of 13 days or more which provide skills to a broad spectrum of specialties without upgrading an individual's "in rating" skill level.

During the 1980's, much attention has been paid to the fact that the "C" school costs are continuously rising in spite of increased retention among trained personnel. Nearly 70 percent of the increase in "total specialized skill training load" from 1979 to 1985 was attributed to "C" schools. The "C" school training load actually increased more than 50 percent during that time frame [Ref. 2].

Studies have shown that formal training produces sailors who become more productive and stay in the Navy longer[1]. However, due to the high costs of advanced skill training, it is incumbent upon Naval manpower

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1 Cost effectiveness of formal training as compared to on-the-job training is discussed in Aline O. Quester and Alan Marcus, "An Evaluation of the Effectiveness of Classroom and On-the-Job Training" Center for Naval Analysis, Alexandria, VA, February 1986, p. 13"

analysts to develop an effective method for ensuring the most cost-efficient number of personnel are trained in "C" schools.

The goal of this thesis is to formulate concepts, data sets and decision programs to improve the current system of meeting billet requirements at the minimum allocation of new inputs (students). The problem of determining the maximum number of personnel from different grade levels who should attend "C" school formal training in the Navy has become increasingly critical. Personnel and monetary resources are becoming more tightly controlled while the U. S. Navy moves towards its 600 ship goal and continues its force modernization during the eighties.

Budget restraints have increased the criticality of accurate yearly forecasts of NEC qualified personnel inventories. A new policy to determine manpower requirements for specialized training must be developed. Key questions of whom to train and how many to train must be answered in order to maximize the total effectiveness of both human and financial capital. The problem is to forecast the NEC inventory by paygrade and to predict the training requirements needed to maintain the prescribed fleet authorizations. These two requirements dictate that OP-112 be able to produce timely predictions of future force levels, training requirements, and the effects of any policy changes concerning retention and advancement within the rating.

This study attempts to formulate a Markov Chain model which will forecast future force levels by NEC. Alternatively, given a pre-determined billet requirement, the same model will be able work in reverse to determine the number of sailors which should be trained. The proposed model will specify annual accessions to formal training needed to maintain future inventories within specified limits of manpower requirements.

II. BACKGROUND

In September 1985, a report by U.S. General Accounting Office (GAO) indicated that, in the past, the Navy has overstated requirements for "C" school, resulting in the current inefficient use of Training Command resources. The GAO has called for an evaluation of organizational relationships and policies that affect the "C" school planning process [Ref. 3]. This study is concerned primarily with the Navy's method of granting quotas for formal training or "C" school associated with the award of an NEC. It is the intent of this thesis to describe the current procedure and its problems, review associated manpower studies, and evaluate the effectiveness of optional solutions. Specific alternatives to current systems will be developed through the integration of research information and formulated concepts.

In order to develop a historical base for this thesis, a background study was conducted focusing primarily on a review of previously completed research papers, program manuals, and instructions relating to force structure inventory models. Contacts and subsequent interviews were conducted with professionals who have concentrations in this area of research.

In the past, Naval manpower analysts have developed various techniques and models to maintain a sufficient inventory of sailors within each general rating. The Navy has conducted extensive research in the area of end strength forecasting, however, except for the Prophet II program discussed later, research has been limited to force projections by rating only.

A literature search has revealed extensive studies in this area centering around recruitment, general rate training, and retention. These studies will serve as a background to current "C" school accession analysis. Discussion of these studies is arranged in chronological order to show the development and sophistication of various modeling techniques.

In 1971, a study by the Naval Personnel and Training Research Laboratory proposed the "Advancement, Strength, and Training Plan ADSTAP". ADSTAP produced an enlisted structure force projection model based on length of service (LOS) utilizing a transition matrix. The study is concerned with recruitment and general rate training quotas, however, the authors did propose further development of their model to include the design of an improved planning system for "C" school [Ref. 4].

In February 1974, the Center for Naval Analyses (CNA) produced "The CNA Officer Projection Model". Although the model pertains to the officer community versus enlisted, it is general enough to have alternate applications [Refs. 5 and 6]. The study concerns a loss projection model run in APL language, quite similar to the methodology incorporated into the model developed in this thesis.

The Prophet system developed in 1978 by CNA analysts successfully predicted force projections by rating using a Markov transition matrix [Ref. 7]. In 1979, CNA developed and published a linear programming model that could predict inventories by enlisted rate for up to seven years [Ref. 8].

The Navy Personnel Research and Development Center (NPRDC) used the Force Structure Projection Computer Model, "FAST" to project second term enlisted manpower supply in 1982. As with the previously described models, "FAST" uses historical transitional data, into, out of, and through the system, to make force structure predictions by rate and rating [Ref. 9]. In July 1985, Rand Corporation published a study promoting a cost-minimizing non-linear programming model to determine incentives needed to fill inventory rate requirements in a steady state [Ref. 10].

Within realistic limitations, the Navy has been able to predict future force level inventories for rates and ratings and has tailored recruiting and initial broad skill training policies towards these goals. These studies were effective in determining future force structure by rate and rating; however, the Navy has very limited experience in attempts to refine forecasts to predict inventories of advanced skilled (NEC holding) personnel. Without accurate forecasting models, the Navy can expect to experience overages and shortages in these areas resulting in hasty personnel policy decisions. These types of decisions inevitably lead to unplanned budget outlays and can negatively effect morale and readiness. The stated problem for this proposed study is to determine an effective allocation of scarce resources, Naval personnel, to NEC producing Navy schools, in order to meet the fleet requirements for each NEC.

An initial, singular, venture to predict force inventories by NEC was proposed by CNA in 1978 with the Prophet II System. Prophet II, a refinement of the previously published Prophet system, projected personnel totals of individual NEC's by LOS and time until expiration of active duty service date (EAOS). The model could be used with either historical transitional probabilities or proposed probabilities estimated from policy changes

[Ref 11]. Prophet II worked well in predicting the total number of people holding certain NEC's, however, its usefulness was limited by detailing assignment conventions with regard to use of NEC holders. Specifically, forecasting models for general ratings are quite useful because, with few exceptions, everyone in the inventory will be used in billets coded to their rating. In contrast, individuals with a certain NEC are often detailed to billets not encoded with that NEC and should be counted as a non-productive member of the inventory. This shortcoming was not addressed until many years later in 1987 in studies conducted by NPRDC. They published their findings in "An Investigation of NEC Utilization" [Ref. 12]. Their primary concern was to determine how many graduates of "C" school were actually being utilized in their academic area of expertise.

NPRDC analysts selected a sample of NEC's and obtained a count of personnel holding each of these NEC's. They then compared those totals with the number of NEC holders who were filling billets which actually required the NEC's. In the U.S. Navy, each sailor holds a billet which is a job position designated by a paygrade, rating, and possibly further defined by an NEC. These NEC's encoded to a billet are called distribution NEC's (DNEC's). They are the same as those awarded in "C" school and thus should be matched to NEC holding personnel for maximum efficiency. In many cases NEC codes have taken the place of ratings as the basis for assignment, increasing the complexity of the detailing procedure. In the NPRDC studies, "utilization" was the term used to describe a match between an individual and a billet with the same NEC.

The results from the analysis by NPRDC in this area show that NEC utilization in the sample studied varied from less than 10 percent to greater than 90 percent by NEC. The sum of total NEC figures indicated that only 63 percent of all NEC holders were utilized in their respective fields. Compounding the deficiencies noted in the initial findings, in fiscal year (FY) 1984, 22 percent of the "C" schools studied trained less than 50 percent of their quotas, while 18 percent trained more than 110 percent.

The heart of the problem is the current policy of planning for "C" school requirements. The methods currently utilized are simple but ineffective. OP-112, the Training Policy Programs Branch of the Navy, totals the number of billets, current and projected, which require a certain NEC. They then divide this total by three, assuming a three year rotation into and out of the billets, and thus arrive at the number of "C" school seats required for that FY. As an alternate planning policy, NPRDC proposes a "C" school planning model which would include data input on billet authorizations, current inventories, school command capacities, historical plans, and NEC utilization percentage.

The major area of the NPRDC plan which requires further investigation is the concept of the NEC utilization figure. To manage the pool of NEC qualified personnel effectively, it is imperative to know the status of NEC holders in relation to NEC encoded billets. To interpret utiliza[illegible] the sailors can be considered in either one of two areas. The first area contains the NEC holders currently filling an NEC encoded billet (utilized) and the second contains NEC holders in non-NEC encoded billets (non-utilized).

Recent interviews with manpower analysts from CNA[2] and NPRDC[3] indicate that both organizations are currently pursuing studies in the field of NEC utilization. NPRDC feels that the percentages obtained from utilization calculations can be used in a manpower model to define "C" school accession policy. However, as one of their reports [Ref. 13] has pointed out, there are difficulties comparing NEC utilization figures with one another due to differences in factors affecting utilization. To use this percentage figure would be too limiting to the model. Each NEC utilization figure is affected by certain factors beyond the control of the planners, that is, different rotation lengths of billets requiring NEC's, shore/sea intensive NEC coded billets, ability to re-use NEC coded personnel, NEC billets restricted to certain paygrades, etc. These factors would cause each NEC utilization figure to be unique. This uniqueness would prohibit the use of utilization figures in a general, flexible model to be used for an overall accession policy. Additionally, a utilization figure is not detailed enough to encompass differences in grade levels required in the inventory.

As an alternate approach to using simple percentage figures, this paper proposes a more comprehensive, adaptive model incorporating the factors which make up the utilization figures. The model addressed in this study offers a prescriptive,universal approach to NEC-specific force projection so that "C" school quotas may be tailored accordingly. In order to plan, justify,

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2 Telephone conversation with Dr. Byrnes, Center for Naval Analyses, Alexandria, VA, 29 July 1987.

3 Telephone conversation with Murray Rowe, Navy Personnel Research and Development Center, San Diego, CA, 24 July 1987.

and audit training requirements, manpower analysts must project accurate personnel forecasts. Budget analysts can then use these forecasts to formulate spending outlays for education pipelines and training commands can prepare for the expected number of students. The overall objective of this study to develop procedural tools attainable with the state-of -the-art to aid and improve the determination of personnel numbers ordered to "C" school so that the Navy's personnel and finances are efficiently utilized.

Through recent years, the U S Navy has continued its fleet expansion and modernization. New systems and technical improvements are introduced into the fleet and are translated into personnel and training requirements. The Markov Chain model demonstrated in this report displays a flexibility which makes it applicable towards shifting manpower demands. Additionally, this specific model can be used as a planning aid for manpower analysts in providing timely predicted outcomes to alternate policy proposals and answering "what if" questions: such as 1.)What will the future distribution of NEC holders be if training continues at status quo and 2) What will the future distribution be if inputs ("C" school graduates) change, by numbers or grade?

III. METHODOLOGY

The Markov Chain model described in this study proposes a realistic alternative to the current OP-112 policy towards "C" school accessions. This model deals with the complex problem of forecasting yearly NEC inventories by paygrade. Mathematical and theoretical concepts pertinent to the formulation of this model will be presented and a future force projection demonstration of the model will be made. Inventory flows are modeled after those observed from historical data; however, the model is based in transition probabilities which can be modified to account for uncertainty in projections or modified by proposed policy changes during the planning horizon. In the Navy, the distribution of losses by paygrade drive increases in training and promotions from lower paygrades.

A. DATA

The experimental model will be demonstrated using the NEC 1127, which was previously described in this report. This particular NEC was chosen because it is influenced by many of the variables which affect other NEC's and increase prediction difficulty. For example, it has a disproportionate number of sea billets compared to shore billets. Its range of billets continues up through the paygrade of E9 necessitating an accurate prediction over many years. Personnel from E1 through E9 are eligible to attend the "C" school leading to this NEC so required personnel can be recruited from any pay grade.

In order to build the model, it was necessary to construct a data set which integrated many facets of information on the career characteristics of those personnel who were classified as 1127. Personnel inventory levels as well as data concerning the rate and rating of 1127 holders were extracted from the Enlisted Master Record (EMR). These data were extremely difficult to compile and the individuals at Defense Manpower Data Center (DMDC) in Monterey, CA were very helpful during the data gathering and verification process. To obtain the historical information for the study, EMR files were compared at fiscal year end points. The computer routines followed individuals by Social Security Number and thus tracked losses and gains, transfers, and promotion rates between October 1 and September 30 of the years studied. DMDC provided additional listings by paygrade of reenlistment, promotion, and separations. All personnel of these listings were further classified by a code describing whether they were utilizing their NEC or not. This additional information provided support and clarification where necessary.

The data were examined following an assumption that the ending inventories are dependent on the beginning inventories plus changes due to promotion, attrition, and recruitment. In this way, the number of personnel acquired from "C" school (recruits) could be identified, the flows from utilization to non-utilization billets, and non-utilization to utilization billets (transfers) could be determined, as well as personnel movements out of the service (attritions). Those who were not on the end of a selected year's files but who appeared on the following year's end point were considered to be recruits. Recruits into the system in this case were those individuals who were graduates from "C" school course A-113-0078. This course is taught in three locations; Fleet Training Center, San Diego, CA, Service School Command, Great Lakes, IL, and the Naval Guided Missile School, VA. The classes convene approximately 11 times a year in each location and run for 187 days.

The recruits, graduates from course A-113-0078, were classified by the type of billet they entered following course completion. Transfers between utilization and non-utilization resulted from orders written by the detailers following the present policy of billet assignment. Attrites are individuals who appear on one year's end point file but not the next. Attritions can be classified as either voluntary or involuntary separations from the service as well as those individuals who had acquired a new NEC.

B. MODEL DEVELOPMENT

To develop the model, the historical data from the EMR was plotted and is illustrated in Tables 1 - 4. A starting inventory is supplied for the end of each FY from the EMR files. The tables show actual numbers of personnel movements by paygrade (E1 - E9) taken from the EMR. "R" equals the number of "C" school graduates, "W" equals the attrites out of the service and those who acquire a new NEC, and the arrows indicate personnel transfers during the fiscal year which is noted at the top of each table. The numbers within the boxes signify those individuals who were in the starting inventory of the subject year.

Initially transition matrices were formulated for all four years studied and displayed as Tables 5 - 8. These tables show actual flow numbers from

TABLE 1
1983 TRANSITIONAL DATA

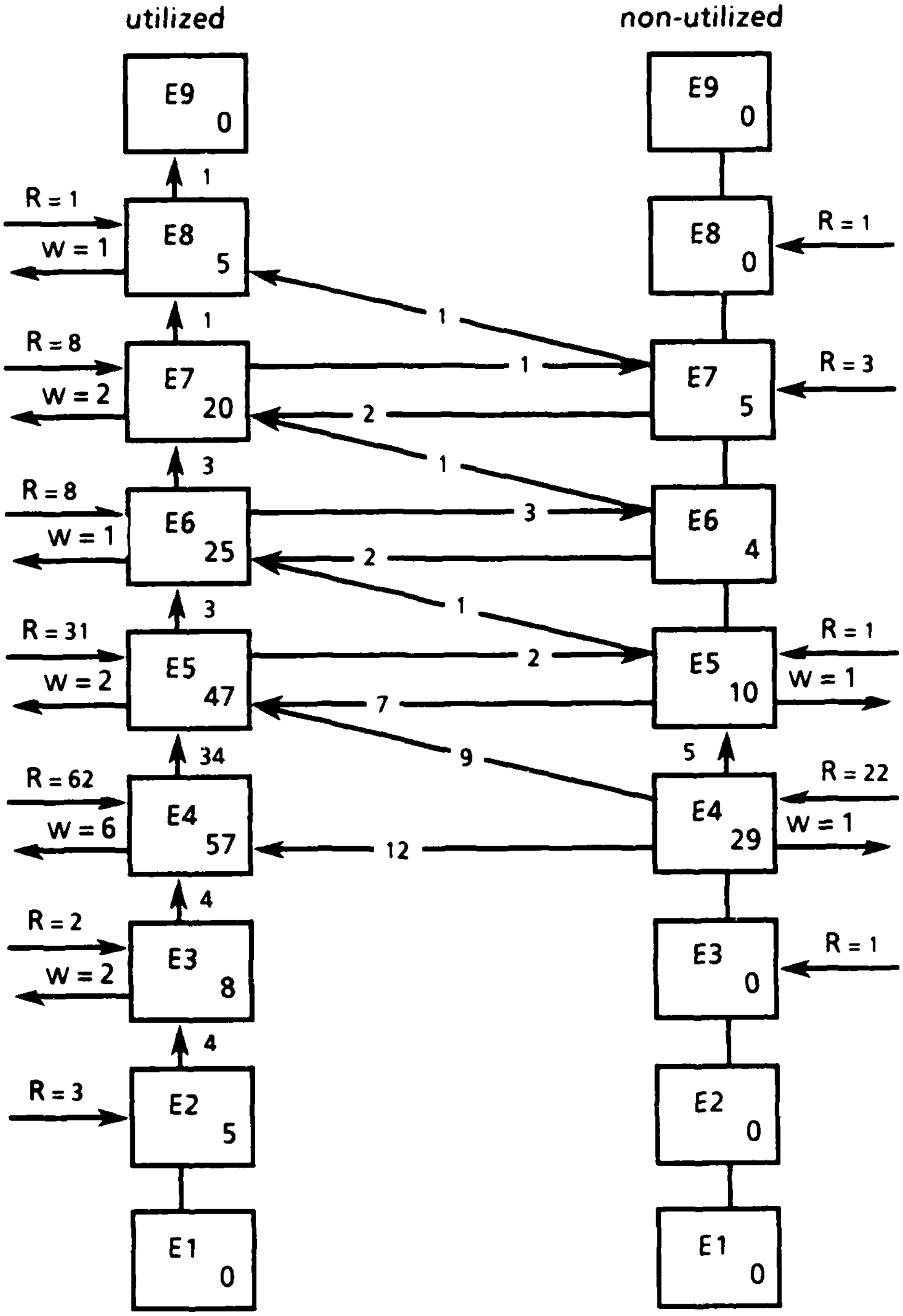


TABLE 2
1984 TRANSITIONAL DATA

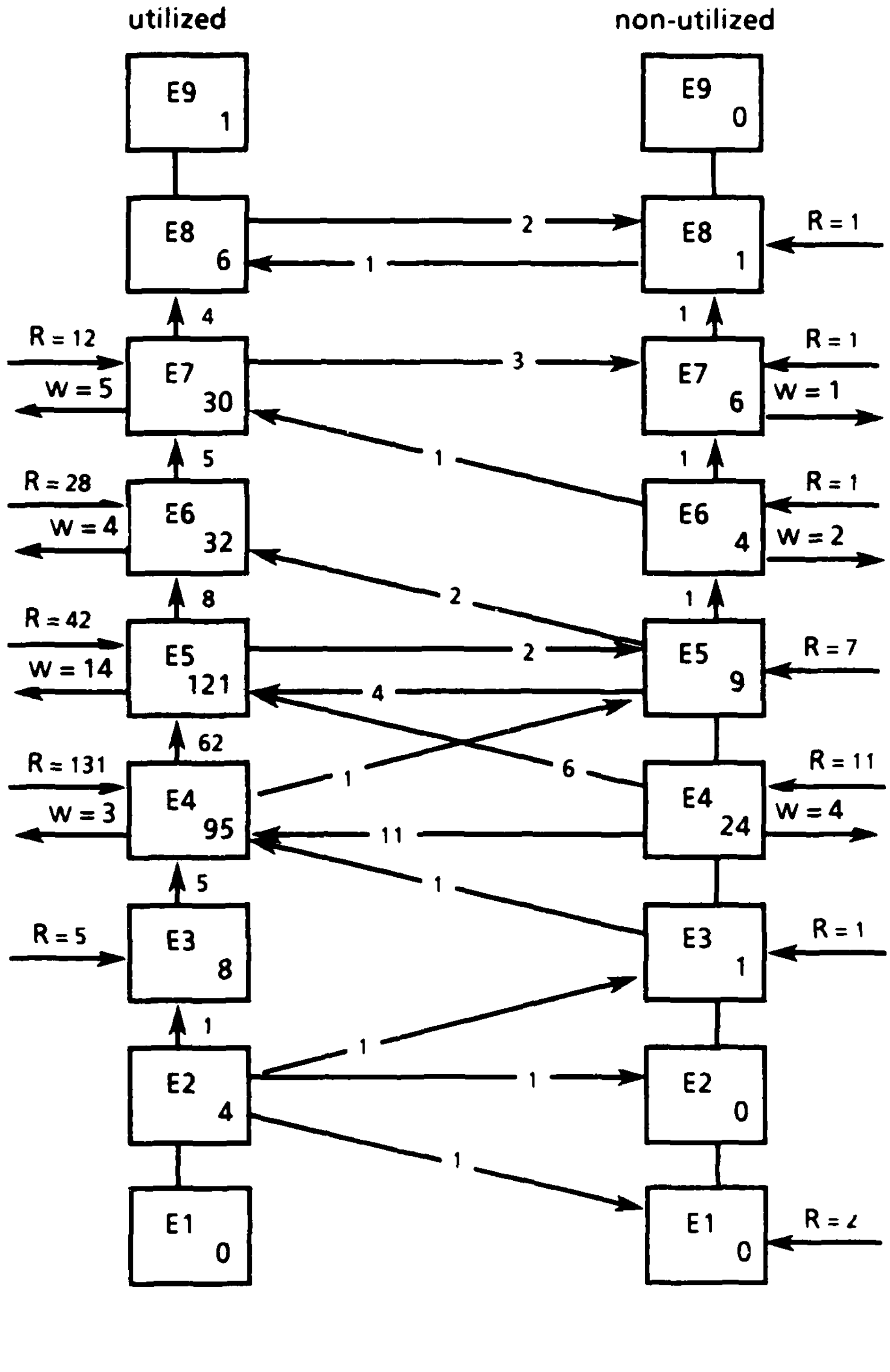


TABLE 3
1985 TRANSITIONAL DATA

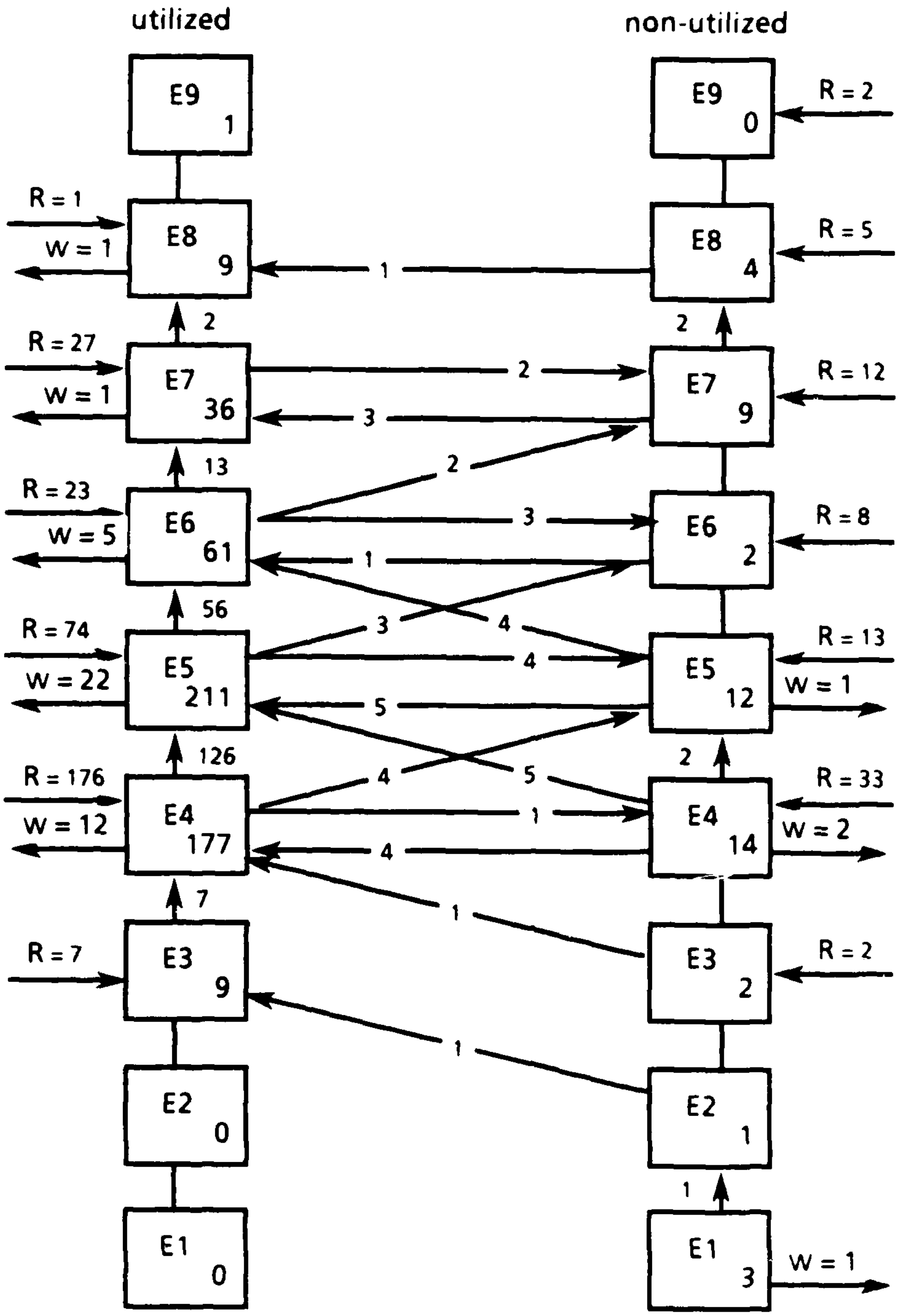


TABLE 4

1986 TRANSITIONAL DATA

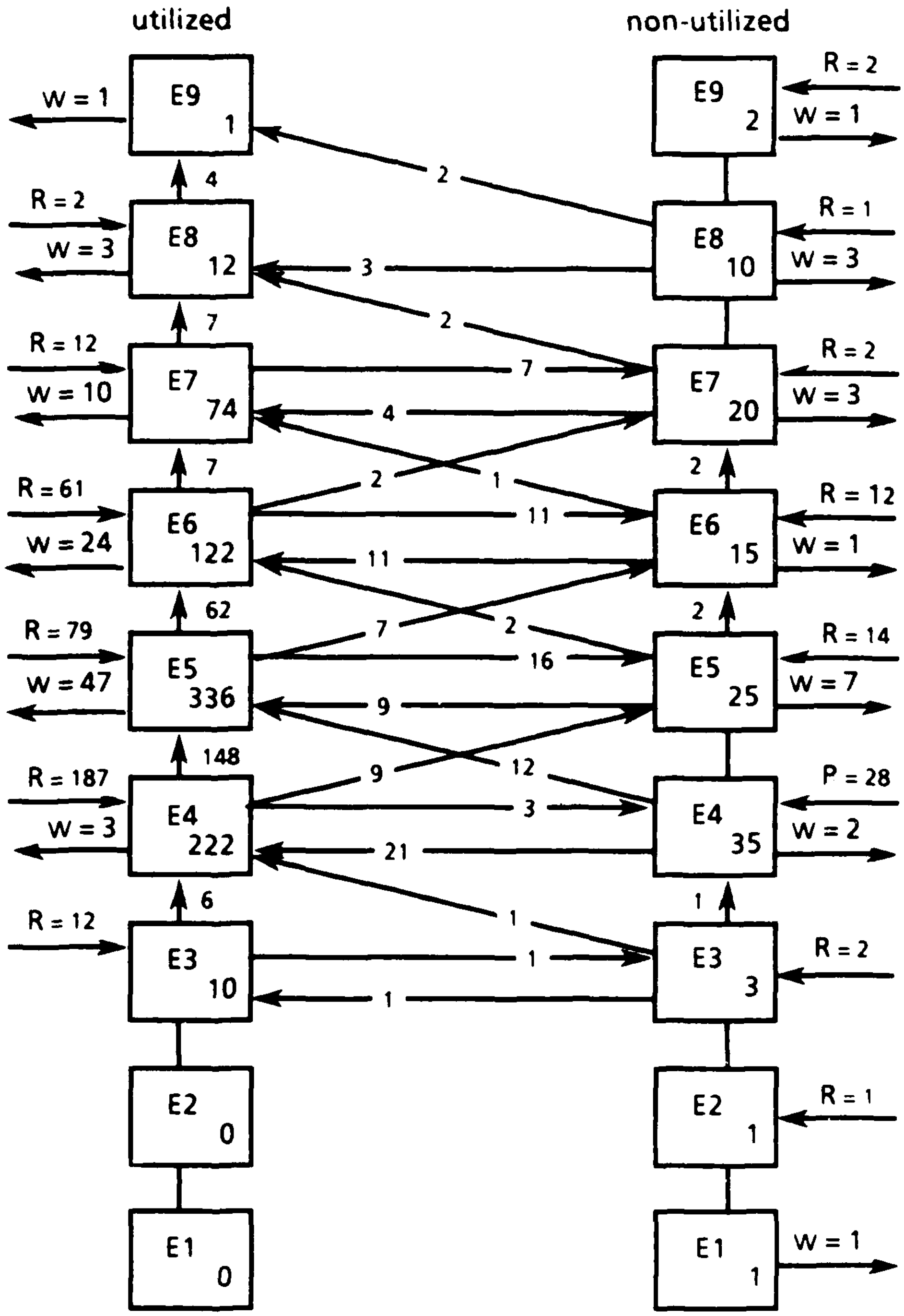


TABLE 5
TRANSITION FIGURES
1983

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E1N	E2N	E3N	E4N	E5N	E6N	E7N	E8N	E9N	W
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
E4	0	0	0	17	34	0	0	0	0	0	0	0	0	0	0	0	0	0	6
E5	0	0	0	0	40	3	0	0	0	0	0	0	0	2	0	0	0	0	2
E6	0	0	0	0	0	18	3	0	0	0	0	0	0	0	3	0	0	0	1
E7	0	0	0	0	0	0	16	1	0	0	0	0	0	0	0	1	0	0	2
E8	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	1
E9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E1N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E4N	0	0	0	12	9	0	0	0	0	0	0	0	2	5	0	0	0	0	1
E5N	0	0	0	0	7	1	0	0	0	0	0	0	0	1	0	0	0	0	1
E6N	0	0	0	0	0	2	1	0	0	0	0	0	0	0	1	0	0	0	0
E7N	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	2	0	0	0
E8N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R	0	3	2	62	31	8	8	1	0	0	0	1	22	1	0	3	1	0	

TABLE 6
TRANSITION FIGURES
1984

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E1N	E2N	E3N	E4N	E5N	E6N	E7N	E8N	E9N	W
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0
E3	0	0	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E4	0	0	0	29	62	0	0	0	0	0	0	0	0	1	0	0	0	0	3
E5	0	0	0	0	97	8	0	0	0	0	0	0	0	2	0	0	0	0	14
E6	0	0	0	0	0	23	5	0	0	0	0	0	0	0	0	0	0	0	4
E7	0	0	0	0	0	0	18	4	0	0	0	0	0	0	0	3	0	0	5
E8	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	2	0	0
E9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
E1N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3N	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E4N	0	0	0	11	6	0	0	0	0	0	0	0	3	0	0	0	0	0	4
E5N	0	0	0	0	4	2	0	0	0	0	0	0	0	2	1	0	0	0	0
E6N	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2
E7N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	1
E8N	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R	0	0	5	131	42	28	12	0	0	2	0	1	11	7	1	1	1	0	

TABLE 7
TRANSITION FIGURES
1985

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E1N	E2N	E3N	E4N	E5N	E6N	E7N	E8N	E9N	W
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3	0	0	2	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E4	0	0	0	34	126	0	0	0	0	0	0	0	1	4	0	0	0	0	12
E5	0	0	0	0	126	56	0	0	0	0	0	0	0	4	3	0	0	0	22
E6	0	0	0	0	0	38	13	0	0	0	0	0	0	0	3	2	0	0	5
E7	0	0	0	0	0	0	31	2	0	0	0	0	0	0	0	2	0	0	1
E8	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	1
E9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
E1N	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1
E2N	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3N	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
E4N	0	0	0	4	5	0	0	0	0	0	0	0	1	2	0	0	0	0	2
E5N	0	0	0	0	5	4	0	0	0	0	0	0	0	2	0	0	0	0	1
E6N	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
E7N	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	4	2	0	0
E8N	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R	0	0	7	176	74	23	27	1	0	0	0	2	33	13	8	12	5	2	

TABLE 8
TRANSITION FIGURES
1986

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E1N	E2N	E3N	E4N	E5N	E6N	E7N	E8N	E9N	W
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3	0	0	3	6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
E4	0	0	0	59	148	0	0	0	0	0	0	0	3	9	0	0	0	0	3
E5	0	0	0	0	204	62	0	0	0	0	0	0	0	16	7	0	0	0	47
E6	0	0	0	0	0	78	7	0	0	0	0	0	0	0	11	2	0	0	24
E7	0	0	0	0	0	0	50	7	0	0	0	0	0	0	0	7	0	0	10
E8	0	0	0	0	0	0	0	5	4	0	0	0	0	0	0	0	0	0	3
E9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
E1N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
E2N	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
E3N	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
E4N	0	0	0	21	12	0	0	0	0	0	0	0	0	0	0	0	0	0	2
E5N	0	0	0	0	9	2	0	0	0	0	0	0	0	5	2	0	0	0	7
E6N	0	0	0	0	0	11	1	0	0	0	0	0	0	0	2	0	0	0	1
E7N	0	0	0	0	0	0	4	2	0	0	0	0	0	0	0	9	2	0	3
E8N	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	2	0	3
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
R	0	1	12	187	79	61	12	2	0	0	0	2	28	14	12	2	1	2	

category to category. Categories in this case are groups of people designated by paygrade and utilization. Tables 9 - 12 display those numbers as proportions of the total number of personnel originating from each category. These transition probabilities between pairs of categories in Tables 9 - 12 were computed using the information gathered from the EMR for the fiscal years studied as shown in Tables 5 - 8. The probability of an individual transferring from category i to category j is denoted as p_{ij}. The number of categories is $k = 18$. Thus the transition probabilities, p_{ij}, are estimated by:

$$\hat{p}_{ij} = n_{ij} / n_i \quad (i,j = 1,2,\ldots 18)$$

Here n_{ij} equals the number of personnel moving from category i to category j during a FY and n_i is the number of personnel in category i at the beginning of the FY.

The transition probabilities can be displayed in the following array

$$\begin{array}{llll} p_{11} & p_{12} \cdots p_{1k} & & w_1 \\ p_{21} & p_{22} \cdots p_{2k} & & w_2 \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ p_{k1} & p_{k2} \cdots p_{kk} & & w_k \end{array}$$

W_i, here, is the probability that a member of category i at the beginning has attrited by the end of the FY. For example: (refer to tables 7 and 11 for the year 1985) - during 1985, 34 out of 177 E4s remained as E4s (34 / 177 = .1921),

TABLE 9
TRANSITION PROBABILITIES
1983

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E1N	E2N	E3N	E4N	E5N	E6N	E7N	E8N	E9N	W
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	.200	.800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3	0	0	.250	.500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.250
E4	0	0	0	.298	.597	0	0	0	0	0	0	0	0	0	0	0	0	0	.105
E5	0	0	0	0	.851	.064	0	0	0	0	0	0	0	.043	0	0	0	0	.042
E6	0	0	0	0	0	.720	.120	0	0	0	0	0	0	0	.120	0	0	0	.040
E7	0	0	0	0	0	0	.800	.050	0	0	0	0	0	0	0	.050	0	0	.1
E8	0	0	0	0	0	0	0	.600	.200	0	0	0	0	0	0	0	0	0	.200
E9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E1N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E4N	0	0	0	.414	.310	0	0	0	0	0	0	0	.069	.172	0	0	0	0	.035
E5N	0	0	0	0	.700	.100	0	0	0	0	0	0	0	.100	0	0	0	0	.100
E6N	0	0	0	0	0	.500	.250	0	0	0	0	0	0	0	.250	0	0	0	0
E7N	0	0	0	0	0	0	.400	.200	0	0	0	0	0	0	0	.400	0	0	0
E8N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R	0	.021	.014	.434	.217	.056	.056	.007	0	0	0	.007	.154	.007	0	.021	.007	0	

TABLE 10
TRANSITION PROBABILITIES
1984

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E1N	E2N	E3N	E4N	E5N	E6N	E7N	E8N	E9N	W
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	0	.250	0	0	0	0	0	0	.250	.250	.250	0	0	0	0	0	0	0
E3	0	0	.375	.625	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E4	0	0	0	.305	.653	0	0	0	0	0	0	0	0	.010	0	0	0	0	.032
E5	0	0	0	0	.802	.066	0	0	0	0	0	0	0	.016	0	0	0	0	.116
E6	0	0	0	0	0	.719	.156	0	0	0	0	0	0	0	0	0	0	0	.125
E7	0	0	0	0	0	0	.600	.133	0	0	0	0	0	0	0	.100	0	0	.167
E8	0	0	0	0	0	0	0	.667	0	0	0	0	0	0	0	0	.333	0	0
E9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
E1N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3N	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E4N	0	0	0	.458	.250	0	0	0	0	0	0	0	.125	0	0	0	0	0	.167
E5N	0	0	0	0	.444	.222	0	0	0	0	0	0	0	.222	.111	0	0	0	0
E6N	0	0	0	0	0	0	.250	0	0	0	0	0	0	0	0	.250	0	0	.500
E7N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.666	.167	0	.167
E8N	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R	0	0	.021	.541	.174	.116	.050	0	0	.008	0	.004	.045	.029	.004	.004	.004	0	

TABLE 11
TRANSITION PROBABILITIES
1985

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E1N	E2N	E3N	E4N	E5N	E6N	E7N	E8N	E9N	W
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3	0	0	.222	.778	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E4	0	0	0	.192	.712	0	0	0	0	0	0	0	.006	.023	0	0	0	0	.068
E5	0	0	0	0	.597	.265	0	0	0	0	0	0	0	.019	.014	0	0	0	.104
E6	0	0	0	0	0	.623	.213	0	0	0	0	0	0	0	.050	.033	0	0	.082
E7	0	0	0	0	0	0	.861	.056	0	0	0	0	0	0	0	.056	0	0	.028
E8	0	0	0	0	0	0	0	.889	0	0	0	0	0	0	0	0	0	0	.111
E9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
E1N	0	0	0	0	0	0	0	0	0	.333	.333	0	0	0	0	0	0	0	.334
E2N	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3N	0	0	0	.500	0	0	0	0	0	0	0	.500	0	0	0	0	0	0	0
E4N	0	0	0	.286	.357	0	0	0	0	0	0	0	.071	.143	0	0	0	0	.143
E5N	0	0	0	0	.417	.333	0	0	0	0	0	0	0	.167	0	0	0	0	.083
E6N	0	0	0	0	0	.500	0	0	0	0	0	0	0	0	.500	0	0	0	0
E7N	0	0	0	0	0	0	0	.444	0	0	0	0	0	0	0	.333	.222	0	0
E8N	0	0	0	0	0	0	0	.250	0	0	0	0	0	0	0	0	.750	0	0
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R	0	0	.018	.460	.193	.060	.017	.003	0	0	0	.005	.086	.034	.021	.031	.013	.005	

TABLE 12
TRANSITION PROBABILITIES
1986

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E1N	E2N	E3N	E4N	E5N	E6N	E7N	E8N	E9N	W
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3	0	0	.300	.600	0	0	0	0	0	0	0	.100	0	0	0	0	0	0	0
E4	0	0	0	.266	.667	0	0	0	0	0	0	0	.013	.041	0	0	0	0	.013
E5	0	0	0	0	.607	.185	0	0	0	0	0	0	0	.048	.021	0	0	0	.140
E6	0	0	0	0	0	.639	.057	0	0	0	0	0	0	0	.090	.016	0	0	.197
E7	0	0	0	0	0	0	.676	.095	0	0	0	0	0	0	0	.095	0	0	.135
E8	0	0	0	0	0	0	0	.417	.333	0	0	0	0	0	0	0	0	0	.250
E9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
E1N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
E2N	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3N	0	0	.333	.333	0	0	0	0	0	0	0	0	.333	0	0	0	0	0	0
E4N	0	0	0	.600	.343	0	0	0	0	0	0	0	0	0	0	0	0	0	.057
E5N	0	0	0	0	.360	.080	0	0	0	0	0	0	0	.200	.080	0	0	0	.280
E6N	0	0	0	0	0	.733	.067	0	0	0	0	0	0	0	.133	0	0	0	.067
E7N	0	0	0	0	0	0	.200	.100	0	0	0	0	0	0	0	.450	.100	0	.150
E8N	0	0	0	0	0	0	0	.300	.200	0	0	0	0	0	0	0	.200	0	.300
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.500	.500
R	0	.002	.029	.451	.190	.147	.029	.005	0	0	0	.005	.068	.034	.029	.005	.002	.005	

1 out of 177 E4s moved to an E4N non-utilization billet (1 / 177 = .0056), 126 out of 177 E4s were promoted to E5 (126 / 177 = .7119), 4 out of 177 E4s were promoted to E5 and transferred to E5N billets (4 / 177 = .0226) , and 12 E4s left the Navy or were awarded a new NEC (12 / 177 = .0678).

To complete the Markov formulation it is necessary to specify the recruitment vector. The recruitment vector can either be maintained as the present status quo to project future force structure under current student assignment policy, or the elements of the recruitment vector can be manipulated to produce a preferred, target outcome. In the example using historical data, the total number of recruits is denoted by R and can be taken directly from Tables 5 - 8. A recruitment proportion vector whose components r1,r2.....rk ($\Sigma ri = 1$) as found in Tables 9 - 12 could be used to denote the probability that each recruit would enter into one of the categories. r_i is calculated by:

$$r_i = R_i / \Sigma R_i$$

A combined matrix with average probabilities was developed using an estimate for the overall flow rate as:

$$p_{ij} = \Sigma n_{ij} / \Sigma n_i$$

These matrices combining all four years of data are displayed as Tables 13 and 14. Table 13 shows actual total flow numbers over all four years from category to category. Table 14 displays those numbers as proportions of the total number of personnel originating from each category. Grades E1 - E3 and grades E1N - E3N were merged together in two categories to overcome the problems of low numbers of individuals in these paygrades.

TABLE 13

COMBINED TRANSITION FIGURES

1983 - 1986

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E1N	E2N	E3N	E4N	E5N	E6N	E7N	E8N	E9N	
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	1	5	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
E3	0	0	10	22	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
E4	0	0	0	139	370	0	0	0	0	0	0	0	4	14	0	0	0	0	24
E5	0	0	0	0	467	129	0	0	0	0	0	0	0	24	10	0	0	0	85
E6	0	0	0	0	0	157	28	0	0	0	0	0	0	0	17	4	0	0	34
E7	0	0	0	0	0	0	115	14	0	0	0	0	0	0	0	13	0	0	18
E8	0	0	0	0	0	0	0	20	5	0	0	0	0	0	0	0	2	0	5
E9	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1
E1N	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1
E2N	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
E3N	0	0	1	3	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
E4N	0	0	0	48	32	0	0	0	0	0	0	0	6	7	0	0	0	0	9
E5N	0	0	0	0	25	9	0	0	0	0	0	0	0	10	3	0	0	0	9
E6N	0	0	0	0	0	14	3	0	0	0	0	0	0	0	4	1	0	0	3
E7N	0	0	0	0	0	0	9	3	0	0	0	0	0	0	0	19	5	0	4
E8N	0	0	0	0	0	0	0	5	2	0	0	0	0	0	0	0	5	0	3
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
R	0	4	26	556	226	120	59	4	0	2	0	6	94	35	21	18	8	4	

TABLE 14

COMBINED TRANSITION PROBABILITIES

1983 - 1986

	E1 - E3	E4	E5	E6	E7	E8	E9	E1N - E3N	E4N	E5N	E6N	E7N	E8N	E9N	W
E1 - E3	.364	.500	0	0	0	0	0	.091	0	0	0	0	0	0	.045
E4	0	.252	.672	0	0	0	0	0	.007	.025	0	0	0	0	.044
E5	0	0	.653	.180	0	0	0	0	0	.034	.014	0	0	0	.119
E6	0	0	0	.654	.117	0	0	0	0	0	.071	.017	0	0	.142
E7	0	0	0	0	.719	.088	0	0	0	0	0	.081	0	0	.113
E8	0	0	0	0	0	.625	.156	0	0	0	0	0	.063	0	.156
E9	0	0	0	0	0	0	.667	0	0	0	0	0	0	0	.333
E1N - E3N	.167	.250	0	0	0	0	0	.333	.083	0	0	0	0	0	.167
E4N	0	.471	.314	0	0	0	0	0	.059	.067	0	0	0	0	.088
E5N	0	0	.446	.161	0	0	0	0	0	.179	.054	0	0	0	.161
E6N	0	0	0	.560	.120	0	0	0	0	0	.160	.040	0	0	.120
E7N	0	0	0	0	.225	.075	0	0	0	0	0	.475	.125	0	.100
E8N	0	0	0	0	0	.333	.133	0	0	0	0	0	.333	0	.200
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	.500	.500
R	.025	.470	.191	.101	.050	.003	0	.007	.080	.030	.018	.015	.007	.003	

Transition probabilities for the four years were then analyzed as proposed by Bartholemew and Forbes to test whether variances in flow rates were due to chance or systematic factors [Ref. 14]. This was accomplished by plotting the transition rates from each matrix cell as a time series along with a confidence interval. The standard error (or measure of variability) for the confidence interval was determined by the formula:

$$\text{standard error} = \{\hat{p}_{ij}\,(1 - \hat{p}_{ij}) \,/\, \bar{n}_i\,\}^{1/2}$$

Where n_i is the average number of personnel in category i over the years combined.

When the individual yearly transition rates were plotted there were a large number of them falling outside of the confidence intervals, especially in the case of the E5 paygrade. The fluctuations in the promotion rates during the years 1983 - 1984 time span versus the 1985 - 1986 time frame were too great to provide a meaningful average. These fluctuations will be discussed in the Conclusions and Recommendations chapter, but for purposes of this study, data from the two most recent years, 1985 and 1986 will be developed. A new combined estimate using these two years alone is given in Tables 15 and 16. Confidence intervals for the 1985 and 1986 data points are shown in Table 17. The top dotted horizontal line indicates the upper limit of the confidence interval, the middle solid horizontal line marks the average probability, and the lower horizontal line if dotted marks the lower limit of the confidence interval. The solid lower horizontal line represents 0 whenever the average probability minus the standard error equals a number less than or equal to 0.

TABLE 15

COMBINED TRANSITION FIGURES

1985 - 1986

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E1N	E2N	E3N	E4N	E5N	E6N	E7N	E8N	E9N	W
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3	0	0	5	13	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
E4	0	0	0	93	274	0	0	0	0	0	0	0	4	13	0	0	0	0	15
E5	0	0	0	0	330	118	0	0	0	0	0	0	0	20	10	0	0	0	69
E6	0	0	0	0	0	116	20	0	0	0	0	0	0	0	14	4	0	0	29
E7	0	0	0	0	0	0	81	9	0	0	0	0	0	0	0	9	0	0	11
E8	0	0	0	0	0	0	0	13	4	0	0	0	0	0	0	0	0	0	4
E9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
E1N	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1
E2N	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
E3N	0	0	1	2	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
E4N	0	0	0	25	17	0	0	0	0	0	0	0	1	2	0	0	0	0	4
E5N	0	0	0	0	14	6	0	0	0	0	0	0	0	7	2	0	0	0	8
E6N	0	0	0	0	0	13	1	0	0	0	0	0	0	0	3	0	0	0	1
E7N	0	0	0	0	0	0	7	2	0	0	0	0	0	0	0	13	4	0	3
E8N	0	0	0	0	0	0	0	4	2	0	0	0	0	0	0	0	5	0	3
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
R	0	1	19	363	153	84	39	3	0	0	0	4	61	27	20	14	6	4	

TABLE 16

COMBINED TRANSITION PROBABILITIES

1985 - 1986

	E1 - E3	E4	E5	E6	E7	E8	E9	E1N - E3N	E4N	E5N	E6N	E7N	E8N	E9N	W
E1 - E3	.250	.650	0	0	0	0	0	.050	0	0	0	0	0	0	.050
E4	0	.233	.687	0	0	0	0	0	.010	.033	0	0	0	0	.038
E5	0	0	.603	.216	0	0	0	0	0	.037	.018	0	0	0	.126
E6	0	0	0	.634	.109	0	0	0	0	0	.077	.022	0	0	.159
E7	0	0	0	0	.736	.082	0	0	0	0	0	.082	0	0	.100
E8	0	0	0	0	0	.619	.191	0	0	0	0	0	0	0	.191
E9	0	0	0	0	0	0	.500	0	0	0	0	0	0	0	.500
E1N - E3N	.200	.200	0	0	0	0	0	.400	.100	0	0	0	0	0	.100
E4N	0	.510	.347	0	0	0	0	0	.020	.041	0	0	0	0	.082
E5N	0	0	.378	.162	0	0	0	0	0	.189	.054	0	0	0	.216
E6N	0	0	0	.722	.056	0	0	0	0	0	.167	0	0	0	.056
E7N	0	0	0	0	.241	.069	0	0	0	0	0	.448	.138	0	.103
E8N	0	0	0	0	0	.286	.143	0	0	0	0	0	.357	0	.214
E9N	0	0	0	0	0	0	0	0	0	0	0	0	0	.500	.500
R	.025	.455	.192	.105	.049	.004	0	.005	.076	.034	.025	.018	.008	.005	

TABLE 17
DATA PLOTS

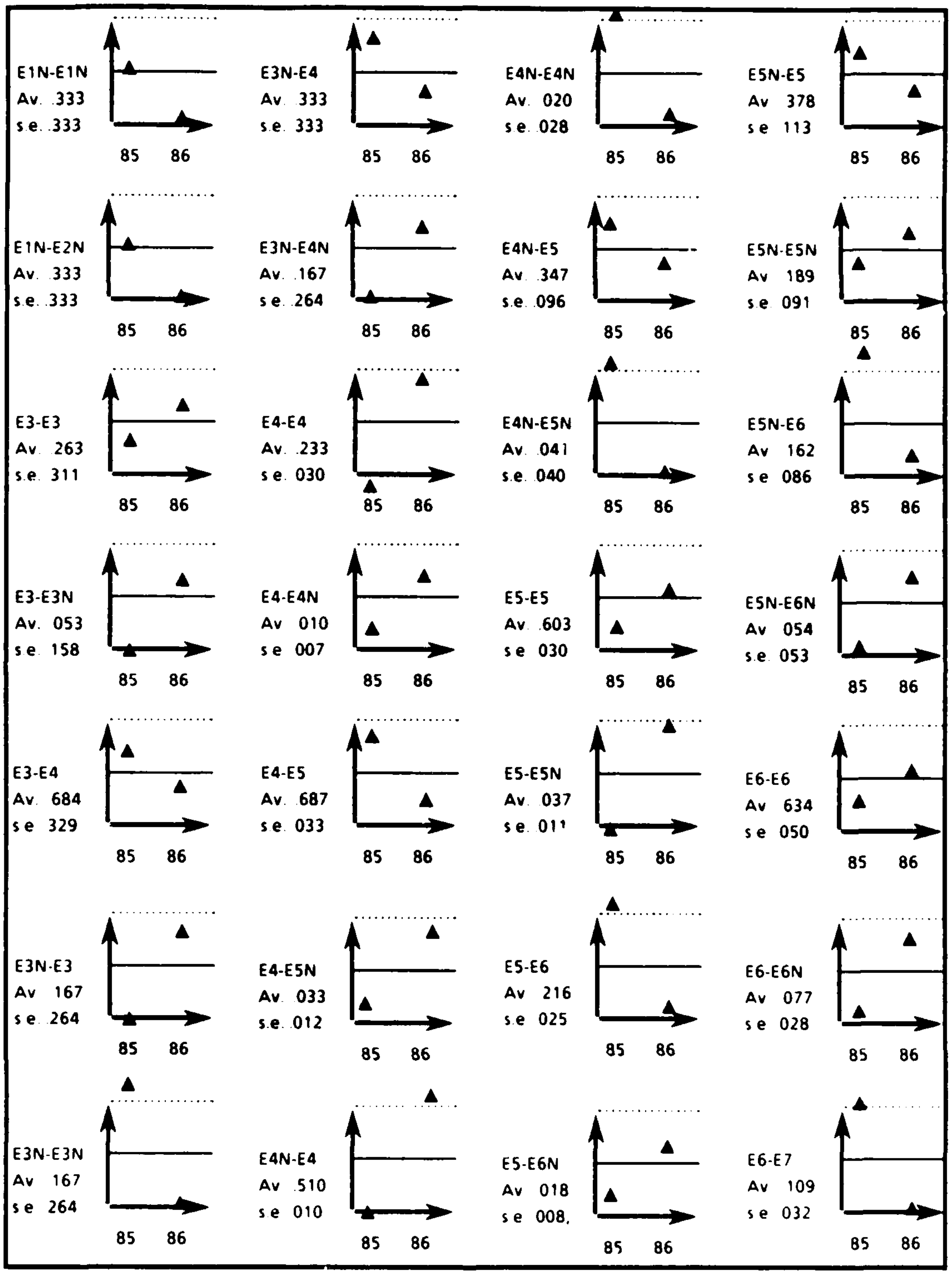
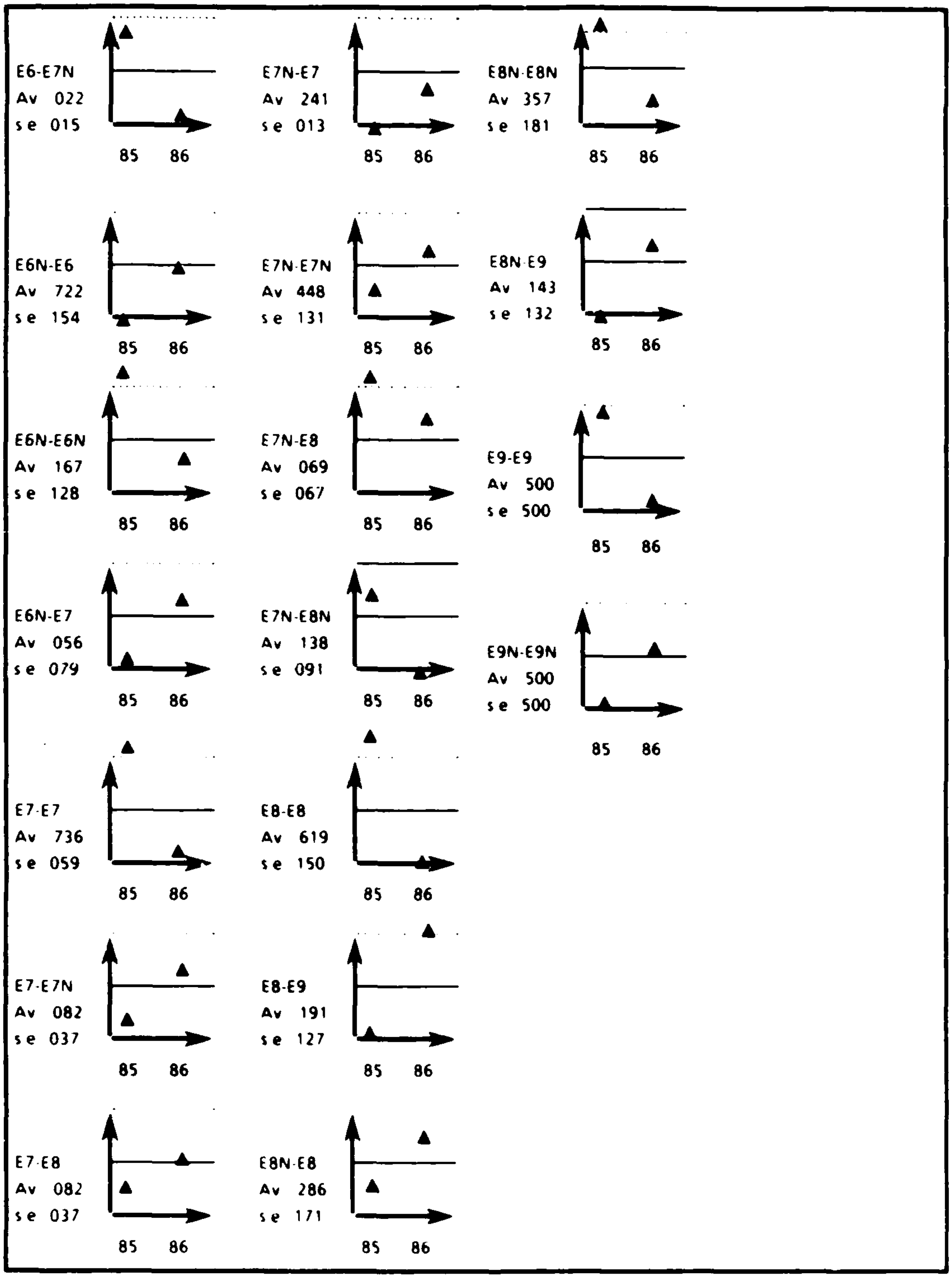


TABLE 17 cont.

DATA PLOTS



The Markov chain model was run using a program written in the APL language on the IBM 3033 computer at the Naval Postgraduate School to produce the calculations shown in Appendixes A, B and C. For comparison purposes the transition proportions from Tables 12, 14, and 16 were each used to forecast stocks for seven years (See Appendixes A,B, and C respectively). All projection routines were run utilizing beginning stock figures from 1986. In all cases a total of 400 recruits were entered into the system each year for seven years using the appropriate recruitment proportion vectors from each table.

IV. RESULTS

The three different transition proportions from the years 1986, 1983 - 1986, and 1985 - 1986 produced three different force structures for seven years, as exhibited in Appendixes A, B, and C. This is a demonstration of how the model can be used to predict force structure over a seven year time frame. This time frame was chosen since it covers two normal three year rotations. The results of the three projections for the seventh year are presented below for comparison purposes. The numbers in parenthesis are percent differences from the 1986 figures, used as an arbitrary basis for comparison. For example: Comparison of the 1985 - 1986 to the 1986 figures for E6 is calculated as [(651 - 645) / 651] x 100 = .9% difference.

	1986	1983 - 1986	1985 - 1986
E1 - E3	19	18 (5.3)	15 (2.1)
E4	273	288 (5.5)	273 (0)
E5	729	845 (15.9)	736 (1.0)
E6	651	588 (9.7)	645 (.9)
E7	152	283 (86.2)	294 (93.4)
E8	32	71 (121.9)	67 (109.4)
E9	11	26 (136.4)	23 (109.0)
E1N -E3N	5	7 (40)	5 (0)
E4N	32	37 (15.6)	34 (6.2)
E5N	74	60 (18.9)	63 (14.9)
E6N	99	70 (29.3)	86 (13.1)
E7N	41	65 (58.5)	68 (65.9)
E8N	6	20 (233.3)	17 (183.3)
E9N	4	2 (50.0)	4 (0)

This comparison is presented to demonstrate the importance of choosing the appropriate model based on historical analysis of transition trends. As expected, the figures derived from the 1985 -1986 transition rates were closer to the 1986 figures, since they were not as effected by the promotion fluctuations between 1984 and 1985. As discussed in the Conclusions and Recommendations chapter additional information concerning patterns of fluctuations would be necessary in order to choose the appropriate model for making accurate force projections. Once the model is chosen, analysts can manipulate the input to produce the desired future force structure. This can be accomplished by changing the total numbers of recruits and possibly the recruitment proportions. "C" school planners would then use these recruit figures with a modification to account for "C" school failure rate to formulate the most efficient total of "C" school seats to be allocated.

The large percent differences between the E8 - E9 and E8N - E9 groups are probably caused by the low numbers of individuals in those categories. A possible solution would be to group the E8s through E9s into one category as was done with the E1s through E3s. However, although E1s are commonly substituted for E3s, it is not generally accepted detailing practice to assign an E8 to an E9 billet. For that reason these two grades were not merged together in this study.

V. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this thesis was to develop an alternative solution to the Navy's current policy concerning "C" school accessions. This study has synthesized information from pertinent literature and current interviews to propose a trial approach to a costly, sensitive issue.

The model used in this project has proven to be a viable means to determine future force inventory by NEC. However, the specific data set, holders of NEC 1127, developed in this thesis did not permit extensive testing of the model. Since the NEC is fairly new, the model suffered for lack of extensive historical data. Additional years of data would have allowed for a test of the model's accuracy. Further research is recommended with older, more populated NEC's.

Additional years of data might also have displayed patterns which would explain the fluctuations in promotion rates between 1983 - 1984 and 1985 - 1986. These fluctuations could have been caused by many factors including the fact that the NEC is newly developed and was experiencing developmental changes, the FC rating underwent various structural changes, and the overall Navy force allocation continued to change according to budget directives. A suggested area for future studies would involve possible correlation between overall promotion rates within the Navy, promotion rates by rating and promotion rates in the NEC's concerned with that rating. This type of research could result in more accurate transition rates for the model. However there are areas which could be improved in present operations to increase the accuracy of the model's predictions.

There are three stages of operations to be performed with the Markov analysis. The first entails gathering the information from the EMR files (transition flows, starting inventory, grade levels). The second stage involves calculation of transition probabilities. The last stage uses the previously correlated data to predict future inventories, and determine inputs needed to meet end strength authorizations.

In order for the model to work, emphasis must be placed on increased awareness of the necessity of timely, accurate NEC record keeping. The channels for maintaining an accurate data base to support NEC planning are in place. Current practices of NEC data submission result in data supplied from/to the EMR which is often inaccurate and out of date. Naval policy makers should ensure that explicit guidance concerning data submission procedures is available to all those who are involved with updating the EMR. Baseline requirements are oriented to the EMR and point out a need for methodical documentation and maintenance of information which should be developed during an expansion of this program.

There are many opportunities in the existing system to improve the quality and timeliness of data recording. Current systems support recommended feasible improvements to eliminate many of the problems associated with NEC reporting. For example, certain "C" schools grant seats to commands with the understanding that the command will upgrade billets with a DNEC to match the graduate's NEC. Often, as in the case of MS 3524

(Bachelor Quarters Management Specialist), the commands are late in changing the billets or never do so. There have also been reported cases of individuals who successfully complete "C" school and, through administrative error, never have the NEC entered into their service record. [Ref. 15].

Another problem involved in NEC inventory prediction concerns the design and implementation of the system which is the subject of the "C" school course. Manpower and thus manpower training requirements for a new weapons system, for example, should be determined during the system's initial design phase. This is not usually the case. It would involve an estimate of the number of enlisted personnel necessary to maintain one system and the number of systems to be installed in the future. Once these requirements are determined, future plans for "C" school requirements can be formulated.

Since NEC studies have been limited in the past, any computer routines which would extract NEC data routinely from the EMR would be costly to initiate. CNA has conducted research in this area with the construction of the "Enlisted Master Record Tracking File". This program extracts data from the EMR to create longitudinal histories for active duty enlisted personnel. Although still in the developmental phase, this procedure already includes a detailed description of an individual's attainment and usage of NEC's [Ref. 16].

Although the 1127 NEC was fairly indicative of other NEC's, there are still some NEC's which would require special attention and program modification. As an example, there are some NEC's which are similar and thus are interchangeable. Among OS's (Operations Specialists) the NEC's of 0312 (OJ-194 Console Operators) and 0317 (NTDS-Input/Utilization Display Equipment Operators) are interchangeable. This would require a computer program that would perform a simultaneous search for both NEC's. Additionally, some "C" schools provide NEC's which cover many ratings. The graduates from these "C" schools are ordered to jobs with different NEC's due to the different ratings. For example a DI 5342 (Diver First Class) may be an EOD technician and would be assigned to a billet 5332 (EOD Diver) while other 5342's are UDT/SEALs who are assigned to 5326 (Combatant Swimmers). Program modifications to accommodate these differences are possible. An alternative, which is beyond the scope of this paper, is to reevaluate the DNEC coding of billets [Ref. 17].

The above arguments indicate that the proposed Markov model that could forecast force structures of all NEC's would be costly to install. However, once the programming details are completed and the administrative channels are in effect, the model could prove to be a cost-efficient way to restrict overuse of "C" school quotas. Once the Markov model is established, it can be used to make force forecasts, keeping inputs as status quo or varying these inputs to test the effects of various career incentives on future force levels. Thus shortfalls and overages could be predicted. Subsequently, school seats would be allotted to those rates which require additional trained personnel to fulfill future requirements. Also, the model could be designed so that the user would either supply gains as current recruitment figures to predict a status quo future force structure or the user could manipulate the recruitment figures to produce a target force design.

There would be additional benefits from this proposed modeling effort. The data collection from the EMR would highlight trends in reenlistment and attrition and also point out potential detailing problems. It is important to balance the Navy's need to recoup "C" school costs by "utilizing" sailors in the job they are trained for, with the sailors' need to receive well rounded rate training which will help them to excel in rating exams.

Improvements can be made to this proposed study to further increase the utility and flexibility of the system. Although the model described in this study does not include actual cost figures, it does provide insight into a measure of cost effectiveness, i.e., the number of individuals to be ordered to "C" school, and could be modified to include cost measures. This model, when fully developed, should yield the most efficient number of qualified sailors for training dollars spent.

Research results from this study should be used as a basis for continuing development and evaluation of these procedures. The usefulness of this model does not end with the development of one "C" school plan. The cost associated with this proposed shift in planning policy can be justified only in terms of savings from efficient use of all "C" schools. The model presented in this study is general enough to be applied to all rates, NEC's and "C" schools.

APPENDIX A

FORCE PROJECTION (Using 1986 transition rates)

```
   START

DO YOU WISH TO ENTER DATA?
 0  NO
 1  YES
J:
   1

ENTER THE NUMBER OF THE MODEL TYPE
 1  MARKOV HIERARCHICAL
 2  MARKOV LENGTH OF SERVICE
 3  MARKOV GENERAL
 4  VACANCY
J:
   3

ENTER N(INITIAL STOCK VECTOR)
J:
   10 222 336 122 74 12 1 5 35 25 15 20 10 2
ENTER P (TRANSITION MATRIX) BY ROWS
ENTER 1TH ROW
J:
   .3 .6 0 0 0 0 0 .1 0 0 0 0 0 0
ENTER 2TH ROW
J:
   0 .226 .667 0 0 0 0 0 .013 .041 0 0 0 0
ENTER 3TH ROW
J:
   0 0 .607 .185 0 0 0 0 0 .048 .021 0 0 0
ENTER 4TH ROW
J:
   0 0 0 .639 .057 0 0 0 0 0 .090 .016 0 0
ENTER 5TH ROW
J:
   0 0 0 0 .676 .095 0 0 0 0 0 .095 0 0
ENTER 6TH ROW
J:
   0 0 0 0 0 .417 .333 0 0 0 0 0 0 0
ENTER 7TH ROW
J:
   0 0 0 0 0 0 0 0 0 0 0 0 0 0
ENTER 8TH ROW
J:
```

```
   .2 .2 0 0 0 0 0 0 .2 .2 0 0 0 0 0 0
ENTER 9TH ROW
J:
   0 .6000 .343 0 0 0 0 0 0 0 0 0 0 0
ENTER 10TH ROW
J:
   0 0 .360 .080 0 0 0 0 0 .200 .080 0 0 0
ENTER 11TH ROW
J:
   0 0 0 .733 .067 0 0 0 0 0 .133 0 0 0
ENTER 12TH ROW
J:
   0 0 0 0 .200 .1 0 0 0 0 0 .450 .1 0
ENTER 13TH ROW
J:
   0 0 0 0 0 .300 .200 0 0 0 0 0 .200 0
ENTER 14TH ROW
J:
   0 0 0 0 0 0 0 0 0 0 0 0 0 .500
ENTER THE NUMBER OF THE RECRUIT TYPE
 1  FIXED RECRUIT VECTOR
 2  ADDITIVE (RECRUIT SIZE)
 3  MULTIPLICATIVE (RECRUIT SIZE)
 4  ADDITIVE (SYSTEM SIZE)
 5  MULTIPLICATIVE (SYSTEM SIZE)
J:
   1
ENTER R (RECRUITMENT VECTOR)
J:
   12 180 76 59 12 2 0 2 27 14 12 2 1 2

ENTER THE PERCENT CODE
 0 NO GRADE PERCENTAGES
 1 GRADE SIZE AS PERCENT OF TOTAL SYSTEM SIZE
 2 GRADE SIZE AS PERCENT OF ORIGINAL GRADE SIZE
 9 QUIT PROGRAM
J:
   1

DO YOU WISH TO
 1  FORECAST STOCKS?
 3  SEE THE DATA?
 5  CHANGE THE DATA?
 7  SEE STEADY STATE?
 9  QUIT THE PROGRAM?
J:
   1

ENTER THE NUMBER OF THE YEAR YOU WISH TO SEE
J:
   7
```

```
DO YOU WISH TO SEE THE INTERVENING YEARS?
 0 NO
 1 YES
J:
   1

 TIME  CTGRY   STOCKS  PERCENT   RECRUITS
= = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = =
= = =
  0  1     10 (     1)
     2    222 (    25)
     3    336 (    38)
     4    122 (    14)
     5     74 (     8)
     6     12 (     1)
     7      1 (     0)
     8      5 (     1)
     9     35 (     4)
    10     25 (     3)
    11     15 (     2)
    12     20 (     2)
    13     10 (     1)
    14      2 (     0)
   TOTAL      889 (    100)
------------------------------------------------
  1  1     16 (     1)
     2    258 (    22)
     3    449 (    38)
     4    212 (    18)
     5     74 (     6)
     6     19 (     2)
     7      6 (     1)
     8      4 (     0)
     9     31 (     3)
    10     44 (     4)
    11     34 (     3)
    12     20 (     2)
    13      5 (     0)
    14      3 (     0)
   TOTAL     1175 (    132)    401
------------------------------------------------
  2  1     18 (     1)
     2    267 (    19)
     3    547 (    39)
     4    306 (    22)
     5     80 (     6)
     6     20 (     1)
     7      7 (     1)
     8      4 (     0)
```

	9	31 (	2)	
	10	55 (	4)	
	11	49 (	3)	
	12	21 (	2)	
	13	4 (	0)	
	14	4 (	0)	
	TOTAL	1414 (	159)	401
3	1	18 (	1)	
	2	271 (	17)	
	3	617 (	38)	
	4	396 (	25)	
	5	91 (	6)	
	6	22 (	1)	
	7	8 (	0)	
	8	5 (	0)	
	9	31 (	2)	
	10	62 (	4)	
	11	62 (	4)	
	12	24 (	1)	
	13	4 (	0)	
	14	4 (	0)	
	TOTAL	1614 (	182)	401
4	1	18 (	1)	
	2	272 (	15)	
	3	664 (	37)	
	4	476 (	27)	
	5	105 (	6)	
	6	23 (	1)	
	7	8 (	0)	
	8	5 (	0)	
	9	31 (	2)	
	10	67 (	4)	
	11	74 (	4)	
	12	28 (	2)	
	13	4 (	0)	
	14	4 (	0)	
	TOTAL	1780 (	200)	401
5	1	18 (	1)	
	2	272 (	14)	
	3	695 (	36)	
	4	546 (	28)	
	5	121 (	6)	
	6	26 (	1)	
	7	9 (	0)	
	8	5 (	0)	
	9	31 (	2)	
	10	70 (	4)	
	11	84 (	4)	

```
     12      32 (     2)
     13       5 (     0)
     14       4 (     0)
   TOTAL   1918 (   216)   401
-----------------------------------------
  6   1      18 (     1)
      2     272 (    13)
      3     716 (    35)
      4     604 (    30)
      5     137 (     7)
      6      29 (     1)
      7       9 (     0)
      8       5 (     0)
      9      31 (     2)
     10      73 (     4)
     11      93 (     5)
     12      37 (     2)
     13       5 (     0)
     14       4 (     0)
   TOTAL   2033 (   229)   401
-----------------------------------------
  7   1      19 (     1)
      2     273 (    13)
      3     729 (    34)
      4     651 (    31)
      5     152 (     7)
      6      32 (     2)
      7      11 (     0)
      8       5 (     0)
      9      32 (     1)
     10      74 (     3)
     11      99 (     5)
     12      41 (     2)
     13       6 (     0)
     14       4 (     0)
   TOTAL   2127 (   239)   401
-----------------------------------------

DO YOU WISH TO
 1  FORECAST STOCKS?
 3  SEE THE DATA?
 5  CHANGE THE DATA?
 7  SEE STEADY STATE?
 9  QUIT THE PROGRAM?
]:
   9
   )OFF HOLD
```

APPENDIX B

FORCE PROJECTION (Using 1983 - 1986 transition rates)

```
    V S A P L  4.0

CLEAR WS
    )LOAD 9 OS4701A
SAVED 16:29:51 10/20/87
WSSIZE IS 672860
    START

DO YOU WISH TO ENTER DATA?
 0  NO
 1  YES
J:
    1

ENTER THE NUMBER OF THE MODEL TYPE
 1  MARKOV HIERARCHICAL
 2  MARKOV LENGTH OF SERVICE
 3  MARKOV GENERAL
 4  VACANCY
J:
    3

ENTER N(INITIAL STOCK VECTOR)
J:
    10 222 336 122 74 12 1 5 35 25 15 20 10 2
ENTER P (TRANSITION MATRIX) BY ROWS
ENTER 1TH ROW
J:
    .364 .5 0 0 0 0 0 .091 0 0 0 0 0 0
ENTER 2TH ROW
J:
    0 .252 .672 0 0 0 0 0 .007 .025 0 0 0 0
ENTER 3TH ROW
J:
    0 0 .653 .180 0 0 0 0 0 .034 .014 0 0 0
ENTER 4TH ROW
J:
    0 0 0 .654 .117 0 0 0 0 0 .071 .017 0 0
ENTER 5TH ROW
J:
    0 0 0 0 .719 .088 0 0 0 0 0 .081 0 0
ENTER 6TH ROW
J:
```

```
  0 0 0 0 0 .625 .156 0 0 0 0 0 .063 0
ENTER 7TH ROW
J:
  0 0 0 0 0 0 .667 0 0 0 0 0 0 0
ENTER 8TH ROW
J:
  .167 .25 0 0 0 0 0 .333 .083 0 0 0 0 0
ENTER 9TH ROW
J:
  0 .471 .314 0 0 0 0 0 .059 .067 0 0 0 0
ENTER 10TH ROW
J:
  0 0 .446 .161 0 0 0 0 0 .179 .053 0 0 0
ENTER 11TH ROW
J:
  0 0 0 .560 .120 0 0 0 0 0 .160 .040 0 0
ENTER 12TH ROW
J:
  0 0 0 0 .225 .075 0 0 0 0 0 .475 .125 0
ENTER 13TH ROW
J:
  0 0 0 0 0 .333 .133 0 0 0 0 0 .333 0
ENTER 14TH ROW
J:
  0 0 0 0 0 0 0 0 0 0 0 0 0 .5
ENTER THE NUMBER OF THE RECRUIT TYPE
 1  FIXED RECRUIT VECTOR
 2  ADDITIVE (RECRUIT SIZE)
 3  MULTIPLICATIVE (RECRUIT SIZE)
 4  ADDITIVE (SYSTEM SIZE)
 5  MULTIPLICATIVE (SYSTEM SIZE)
J:
   1
ENTER R (RECRUITMENT VECTOR)
J
   10 188 76 40 20 1 0 3 32 12 7 6 3 1

ENTER THE PERCENT CODE
 0 NO GRADE PERCENTAGES
 1 GRADE SIZE AS PERCENT OF TOTAL SYSTEM SIZE
 2 GRADE SIZE AS PERCENT OF ORIGINAL GRADE SIZE
 9 QUIT PROGRAM
J
   1

DO YOU WISH TO
 1  FORECAST STOCKS?
 3  SEE THE DATA?
 5  CHANGE THE DATA?
 7  SEE STEADY STATE?
 9  QUIT THE PROGRAM?
```

```
J:
   1

ENTER THE NUMBER OF THE YEAR YOU WISH TO SEE
J:
   7

DO YOU WISH TO SEE THE INTERVENING YEARS?
 0 NO
 1 YES
J:
   1


 TIME  CTGRY   STOCKS  PERCENT   RECRUITS
=========================================
===
  0  1       10 (      1)
     2      222 (     25)
     3      336 (     38)
     4      122 (     14)
     5       74 (      8)
     6       12 (      1)
     7        1 (      0)
     8        5 (      1)
     9       35 (      4)
     10       25 (      3)
     11       15 (      2)
     12       20 (      2)
     13       10 (      1)
     14        2 (      0)
   TOTAL       889 (    100)
-----------------------------------------
  1  1       14 (      1)
     2      267 (     22)
     3      467 (     39)
     4      193 (     16)
     5       94 (      8)
     6       20 (      2)
     7        4 (      0)
     8        6 (      0)
     9       36 (      3)
     10       36 (      3)
     11       24 (      2)
     12       24 (      2)
     13       10 (      1)
     14        2 (      0)
   TOTAL      1195 (    134)    399
-----------------------------------------
  2  1       16 (      1)
     2      281 (     19)
```

	3	587 (	40)	
	4	269 (	18)	
	5	118 (	8)	
	6	27 (	2)	
	7	7 (	0)	
	8	6 (	0)	
	9	36 (	2)	
	10	43 (	3)	
	11	33 (	2)	
	12	29 (	2)	
	13	10 (	1)	
	14	2 (	0)	
TOTAL		1466 (	165)	399
3	1	17 (	1)	
	2	286 (	17)	
	3	679 (	40)	
	4	347 (	20)	
	5	147 (	9)	
	6	34 (	2)	
	7	10 (	1)	
	8	7 (	0)	
	9	37 (	2)	
	10	49 (	3)	
	11	42 (	2)	
	12	35 (	2)	
	13	12 (	1)	
	14	2 (	0)	
TOTAL		1703 (	192)	399
4	1	17 (	1)	
	2	287 (	15)	
	3	745 (	39)	
	4	421 (	22)	
	5	179 (	9)	
	6	42 (	2)	
	7	14 (	1)	
	8	7 (	0)	
	9	37 (	2)	
	10	53 (	3)	
	11	50 (	3)	
	12	42 (	2)	
	13	13 (	1)	
	14	2 (	0)	
TOTAL		1910 (	215)	399
5	1	17 (	1)	
	2	288 (	14)	
	3	791 (	38)	
	4	486 (	23)	
	5	214 (	10)	

```
        6     50 (     2)
        7     17 (     1)
        8      7 (     0)
        9     37 (     2)
       10     57 (     3)
       11     58 (     3)
       12     50 (     2)
       13     15 (     1)
       14      2 (     0)
    TOTAL     2089 (   235)   399
-----------------------------------------
    6   1     17 (     1)
        2    288 (    13)
        3    823 (    37)
        4    542 (    24)
        5    249 (    11)
        6     60 (     3)
        7     22 (     1)
        8      7 (     0)
        9     37 (     2)
       10     59 (     3)
       11     65 (     3)
       12     58 (     3)
       13     18 (     1)
       14      2 (     0)
    TOTAL     2245 (   253)   399
-----------------------------------------
    7   1     18 (     1)
        2    288 (    12)
        3    845 (    35)
        4    588 (    25)
        5    283 (    12)
        6     71 (     3)
        7     26 (     1)
        8      7 (     0)
        9     37 (     2)
       10     60 (     3)
       11     70 (     3)
       12     65 (     3)
       13     20 (     1)
       14      2 (     0)
    TOTAL     2380 (   268)   399
-----------------------------------------
DO YOU WISH TO
 1  FORECAST STOCKS?
 3  SEE THE DATA?
 5  CHANGE THE DATA?
 7  SEE STEADY STATE?
 9  QUIT THE PROGRAM?
J:
  9
```

APPENDIX C

FORCE PROJECTION (Using 1985 - 1986 transition rates)

```
    V S A P L  4.0

CLEAR WS
    )LOAD 9 OS4701A
SAVED 16:29:51 10/20/87
WSSIZE IS 664668
    START

DO YOU WISH TO ENTER DATA?
 0  NO
 1  YES
J:
    1

ENTER THE NUMBER OF THE MODEL TYPE
 1  MARKOV HIERARCHICAL
 2  MARKOV LENGTH OF SERVICE
 3  MARKOV GENERAL
 4  VACANCY
J:
    3

ENTER N(INITIAL STOCK VECTOR)
J:
    10 222 336 122 74 12 1 5 35 25 15 20 10 2
ENTER P (TRANSITION MATRIX) BY ROWS
ENTER 1TH ROW
J:
    .25 .65 0 0 0 0 0 0 .05 0 0 0 0 0 0
ENTER 2TH ROW
J:
    0 .233 .687 0 0 0 0 0 .010 .033 0 0 0 0
ENTER 3TH ROW
J:
    0 0 .603 .216 0 0 0 0 0 .037 .018 0 0 0
ENTER 4TH ROW
J:
    0 0 0 .634 .109 0 0 0 0 0 .077 .022 0 0
ENTER 5TH ROW
J:
    0 0 0 0 .736 .082 0 0 0 0 0 .082 0 0
ENTER 6TH ROW
J:
```

```
 00000.619.1910000000
ENTER 7TH ROW
J:
 000000.5000000000
ENTER 8TH ROW
J:
 .2.2000000.4.100000
ENTER 9TH ROW
J:
 0.510.34700000.020.0410000
ENTER 10TH ROW
J:
 00.378.16200000.189.054000
ENTER 11TH ROW
J:
 000.722.05600000.167000
ENTER 12TH ROW
J:
 0000.241.06900000.448.1380
ENTER 13TH ROW
J:
 00000.286.14300000.3570
ENTER 14TH ROW
J:
 0000000000000.5
ENTER THE NUMBER OF THE RECRUIT TYPE
 1 FIXED RECRUIT VECTOR
 2 ADDITIVE (RECRUIT SIZE)
 3 MULTIPLICATIVE (RECRUIT SIZE)
 4 ADDITIVE (SYSTEM SIZE)
 5 MULTIPLICATIVE (SYSTEM SIZE)
J:
 1
ENTER R (RECRUITMENT VECTOR)
J:
 10 182 77 42 20 2 0 2 30 14 10 7 3 2

ENTER THE PERCENT CODE
 0 NO GRADE PERCENTAGES
 1 GRADE SIZE AS PERCENT OF TOTAL SYSTEM SIZE
 2 GRADE SIZE AS PERCENT OF ORIGINAL GRADE SIZE
 9 QUIT PROGRAM
J:
 1

DO YOU WISH TO
 1 FORECAST STOCKS?
 3 SEE THE DATA?
 5 CHANGE THE DATA?
 7 SEE STEADY STATE?
 9 QUIT THE PROGRAM?
```

```
J:
   1

ENTER THE NUMBER OF THE YEAR YOU WISH TO SEE
J:
   7

DO YOU WISH TO SEE THE INTERVENING YEARS?
 0 NO
 1 YES
J:
   1


 TIME  CTGRY   STOCKS  PERCENT   RECRUITS
======================================
===============
  0   1      10 (     1)
      2     222 (    25)
      3     336 (    38)
      4     122 (    14)
      5      74 (     8)
      6      12 (     1)
      7       1 (     0)
      8       5 (     1)
      9      35 (     4)
     10      25 (     3)
     11      15 (     2)
     12      20 (     2)
     13      10 (     1)
     14       2 (     0)
    TOTAL      889 (    100)
------------------------------------------
  1   1      14 (     1)
      2     259 (    22)
      3     454 (    38)
      4     207 (    17)
      5      93 (     8)
      6      20 (     2)
      7       4 (     0)
      8       5 (     0)
      9      33 (     3)
     10      40 (     3)
     11      29 (     2)
     12      25 (     2)
     13       9 (     1)
     14       3 (     0)
    TOTAL     1195 (    134)    401
------------------------------------------
  2   1      14 (     1)
      2     269 (    18)
```

	3	555 (38)	
	4	299 (20)	
	5	119 (8)	
	6	26 (2)	
	7	7 (0)	
	8	4 (0)	
	9	34 (2)	
	10	48 (3)	
	11	41 (3)	
	12	30 (2)	
	13	10 (1)	
	14	4 (0)	
TOTAL		1461 (164)	401
3	1	14 (1)	
	2	272 (16)	
	3	627 (37)	
	4	389 (23)	
	5	150 (9)	
	6	33 (2)	
	7	10 (1)	
	8	5 (0)	
	9	34 (2)	
	10	54 (3)	
	11	52 (3)	
	12	37 (2)	
	13	11 (1)	
	14	4 (0)	
TOTAL		1691 (190)	401
4	1	15 (1)	
	2	273 (14)	
	3	674 (36)	
	4	471 (25)	
	5	184 (10)	
	6	40 (2)	
	7	13 (1)	
	8	5 (0)	
	9	34 (2)	
	10	58 (3)	
	11	63 (3)	
	12	44 (2)	
	13	12 (1)	
	14	4 (0)	
TOTAL		1888 (212)	401
5	1	15 (1)	
	2	273 (13)	
	3	704 (34)	
	4	541 (26)	
	5	221 (11)	

```
      6     48 (     2)
      7     16 (     1)
      8      5 (     0)
      9     34 (     2)
     10     60 (     3)
     11     72 (     3)
     12     52 (     3)
     13     13 (     1)
     14      4 (     0)
   TOTAL     2058 (   231)   401
------------------------------------------
  6   1     15 (     1)
      2    273 (    12)
      3    724 (    33)
      4    599 (    27)
      5    258 (    12)
      6     58 (     3)
      7     19 (     1)
      8      5 (     0)
      9     34 (     2)
     10     62 (     3)
     11     80 (     4)
     12     60 (     3)
     13     15 (     1)
     14      4 (     0)
   TOTAL     2205 (   248)   401
------------------------------------------
  7   1     15 (     1)
      2    273 (    12)
      3    736 (    32)
      4    645 (    28)
      5    294 (    13)
      6     67 (     3)
      7     23 (     1)
      8      5 (     0)
      9     34 (     1)
     10     63 (     3)
     11     86 (     4)
     12     68 (     3)
     13     17 (     1)
     14      4 (     0)
   TOTAL     2330 (   262)   401
------------------------------------------

DO YOU WISH TO
 1  FORECAST STOCKS?
 3  SEE THE DATA?
 5  CHANGE THE DATA?
 7  SEE STEADY STATE?
 9  QUIT THE PROGRAM?
J:
```

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