To the Graduate Council:

I am submitting herewith a thesis written by David Joseph Soukup entitled "A Markov Analysis of Fund-Raising Alternatives." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Industrial Engineering.

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A MARKOV ANALYSIS OF FUND-RAISING ALTERNATIVES

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

David Joseph Soukup

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ABSTRACT

This study explores the strategies of fund raising for a nonprofit organization to maximize net income. The giving pattern of the members of the organization was modelled as a Markov chain.

A mailing test was conducted to examine one alternative with inconclusive results. The remaining alternatives were analyzed using Howard's Value-Determination Policy-Improvement method and the optimum strategy was found. Some parameters were varied to investigate the sensitivity of the solution to changes.

The study is an application of a modern analysis technique to an area not usually associated with analytical methods.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

CHAPTER I

STATEMENT OF THE PROBLEM

The problems industrial engineering students typically deal with in courses in engineering economy, mathematical programming, and decision theory are geared toward profit-making organizations. Improving productivity, one of the goals of the industrial engineer, is the basis of increasing profits. However, more and more hospitals, government agencies, and other nonprofit organizations are realizing that in order to maintain or improve their levels of service they must call upon the industrial engineer.

Service industries, including hospitals and nonprofit organizations, must bear some blame for the nation's high rate of inflation because increases in their productivity rates have lagged behind gains in manufacturing industries. Inflationary pressure is caused by service workers' increasing wage demands exceeding growth in their output. Since an increasing proportion of the nation's population is joining the service sector, the inflation rate will continue to climb unless these industries' methods of operation are improved.

Nonprofit organizations face the cash flow and personnel problems which profit-making concerns confront. But there are significant differences in other aspects of management. Financing the corporation is one such problem.

Profit-making firms rely on the sale of stocks, commercial paper, and corporate bonds in order to raise cash to finance their operations.

Nonprofit organizations rely heavily on contributions from the public to fund their programs.

Receipt of foundation grants, large individual gifts, and bequests depends on such factors as the leadership of the organization and the skill of the grantswriter—variables which are difficult to quantify. These sources accounted for only 17 percent of the $38 billion in contributions made in the United States during 1978 (government grants to nonprofit organizations are not included in this figure).[1]

The other 83 percent came from living individuals who made their gifts in response to a telephone solicitation, a telethon, or one of the many other methods of conducting fund-raising.

An increasingly popular way to raise funds is through direct mail. Political organizations are becoming dependent on this method, as well. Fund raisers segment the audience of potential contributors, knowing that some groups will respond better than others, both in terms of the average gift amount and percentage which actually contribute. So, the fund-raising problem is similar to a profit-making organization's marketing problem. Advertisers know that some market segments will respond better than others so they target these groups for special treatment, rather than making a general appeal to the entire population.

This study will consider the history of direct mail fund-raising conducted by the Tau Beta Pi Association, Inc., the national engineering honor society, which is a nonprofit educational corporation. The method

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[1]Fred Schnaue, Giving USA, (New York: American Association of Fund-Raising Counsel), p. 6.

will be to derive a mathematical model of the giving pattern over the past seven years, conduct an experiment to test the value of segmenting an audience as opposed to making a general appeal, and to recommend a policy for fund-raising over the long term.

The association's solicitation mailing list for a given year is broken into seven categories:

New Member—Has just been put on the mailing list. Has never been solicited in the past.

Non-Donor—Has been solicited in the past at least once, but has never contributed.

First-time Donor—Gave one or more gifts during the last fiscal year totalling less than $50. Had not given prior to that year.

Renewed Donor—Gave one or more gifts last fiscal year totalling less than $50. Had given at least once in previous years, although the previous gifts may not have come in consecutive years.

Major Donor—Gave one or more gifts during last fiscal year totalling at least $50. This category includes members whose first-ever donation was $50 or more, making those members Major Donors rather than First-time Donors.

Lapsed Donor—Did not give last year, but contributed at least once in the past. His or her last gift(s) during a year totalled less than $50.

Lapsed Major—Did not give last year, but contributed at least once in the past. His or her last gift(s) during a year totalled $50 or more.

Each of these groups is solicited differently based on the revenue each category is expected to generate. That is, Major Donors receive their appeals via first class mail, whereas Non-Donors receive theirs by third class bulk mail. The cost per member mailed to varies according to the category.

The movements from one category to another can possibly be modelled as a first-order Markov chain. Another state will be added to those previously defined, an absorbing state, Dead or Lost. That is, once a person dies or can no longer be reached because of a bad address he or she will never receive another solicitation. This is a simplification because a few individuals whose addresses are not valid do get back onto the mailing list by voluntarily reporting their new addresses. Figure 1 shows the form the Markov chain matrix would take.

A zero in the ijth cell indicates that a transition is not possible from the ith state at time t to the jth state in time t + 1. A p_{ij} in a cell indicates that the transition is possible.

The first problem is to determine the values of the p_{ij}'s. The historical giving records available for each member list the amounts of each gift and the dates made. So, to derive one p_{ij} one must count the number of members in a given category i at time t and then note how many of them wind up in category j in time t + 1.

state in year t + 1 / state in year t	Major Donor	Lapsed Major	First-time Donor	Renewed Donor	Lapsed Donor	Non-Donor	New Member	Dead or Lost
Major Donor	p_{11}	p_{12}	0	p_{14}	0	0	0	p_{18}
Lapsed Major	p_{21}	p_{22}	0	p_{24}	0	0	0	p_{28}
First-time Donor	p_{31}	0	0	p_{34}	p_{35}	0	0	p_{38}
Renewed Donor	p_{41}	0	0	p_{44}	p_{45}	0	0	p_{48}
Lapsed Donor	p_{51}	0	0	p_{54}	p_{55}	0	0	p_{58}
Non-Donor	p_{61}	0	p_{63}	0	0	p_{66}	0	p_{68}
New Member	p_{71}	0	p_{73}	0	0	p_{76}	0	p_{78}
Dead or Lost	0	0	0	0	0	0	0	1

Figure 1. Markov chain matrix of Tau Beta Pi donors.

For example, if the giving record for an individual is:

1972 — $10

1973 — $ 0

1974 — $25

1975 — $75

he or she starts in the First-time Donor category (a gift of less than $50 made in 1972), moves to the Lapsed Donor category in 1973 because no gift was made in 1973, then goes to the Renewed Donor category, and winds up in the Major Donor category since the 1975 gift of $75 exceeded $50.

Given the transition statistics, it is hypothesized that the transition probabilities, p_{ij}, do not vary over the seven data supported years of the program and that the chain is indeed a first-order chain.

Also the study will determine whether any of the states can be "merged." For example, if the row of transition probabilities for Lapsed Donors is the same as for Renewed Donors there may be no use in distinguishing them for solicitation purposes. One would spend the same amount per person to solicit a contribution in each of the two categories, Renewed Donor and Lapsed Donor.

A number of other useful statistics, including the probability that a person will donate at least once before leaving the system, can be derived from the chain.

The segmentation described earlier is based solely on past giving or nongiving. Nondonors are actually further broken down into three categories:

Life subscriber—person has paid $35.00 for a life subscription to the association's quarterly magazine.

Annual renewer—person has paid $3.00 for a one year's subscription to the magazine.

Nonsubscriber—person does not have a magazine subscription.

Less than one out of twenty Non-Donors in 1977 became either First-time Donors or Major Donors in 1978 (as compared to 75 percent of the Major Donors in 1977 becoming either Renewed Donors or remaining Major Donors in 1978), according to data collected by Tau Beta Pi's fund-raiser. Those Non-Donors who have a life subscription to the magazine had a slightly better giving percentage than the annual renewers and nonsubscribers.

Another type of segmentation may prove useful in convincing Non-Donors to contribute. The Non-Donor nonsubscribers were broken into two groups to test this theory. One group, the control group, received a standard letter. The second, the experimental group, was divided into two segments—those who joined the organization as juniors and those who joined the organization as seniors. One must be in the top eighth of the junior class in engineering to be academically eligible to join, or in the top fifth of the senior class. Those who came in as juniors would receive a letter noting that they joined as juniors while those who came in as seniors would receive a differently worded letter appealing to them based on the fact that they became members as seniors in engineering. The matrix below summarizes the experiment (Figure 2):

	Junior	Senior
Standard Letter	p_{11}	p_{12}
Differentiated Letter	p_{21}	p_{22}

Figure 2. Fund-raising experiment matrix.

The hypothesis was that p_{21} the percentage of juniors donating as a result of receiving the differentiated letter, will be greater than p_{11} the percentage of juniors responding to the standard letter and that p_{22} will, similarly, be greater than p_{12}. Another hypothesis was that members who joined Tau Beta Pi as juniors show more "loyalty" to the organization since they had more time to participate in its activities. Hence, they would be more likely to give, so p_{11} would be greater than p_{12} and p_{21} would be greater than p_{22}.

A random sample of 2,000 Non-Donor nonsubscribers identified by the Tau Beta Pi fund-raiser was obtained and research done on their backgrounds. Half of those persons who became members as juniors received a standard letter while the other half received the differentiated letter. The persons who came in as seniors were treated similarly.

Given the results of the historical modelling and segmentation experiment described above, a model to determine long-term strategy using the Value Iteration technique with discounting was derived.

The basis of Markovian decision making is the reward vector, with elements r_{ij} operating on the associated probability vector, with elements p_{ij}. Given that one is in state i at time t, a certain policy could get one into state j with probability $p_{ij(1)}$ with an associated reward $r_{ij(1)}$, while a second alternative gets one to state j with a different probability $p_{ij(2)}$ and different reward $r_{ij(2)}$. The decision among the possible alternatives is based on a long-term analysis using the Value Iteration technique.

Tau Beta Pi's fund-raiser proposed three different strategies for the five-year span 1980-85. The first consisted of an aggressive campaign to convince more Renewed Donors to become Major Donors, and inducing Non-Donors to become First-time Donors. The second option focused on the same audiences as the first, but the number of mailings to each group was lower, so the costs were not as high. The third option eliminated Non-Donors from the solicitation. Only individuals who gave in the past would be solicited. The three proposals were evaluated by the fund-raiser by totalling expected revenue and costs for the five years. The total cost for the first proposal was higher than the other two, but the total revenue was much higher, meaning that the net income over the five years would be highest under plan number 1. No discounting was utilized, however, to reflect the uncertainty in the number of donors and the average donation.

These alternatives will be put into a Markov chain framework. The transition probabilities will be estimated from the historical model and from the fund-raiser's projections. The elements of the reward vectors will be the net revenue or loss resulting from going from state i to state j. These net reward values, r_{ij}, equal the expected income minus the expected cost for soliciting one person in state i who makes the transition to state j.

After the optimum strategies are found, sensitivity analysis on the model's parameters will be run. This will show the effects changes in the discount factor, the transition probabilities, p_{ij} and the rewards, r_{ij} have on the outcome.

The paper concludes with recommendations on long-term fund-raising strategy, additions to the data base, and areas of future research.

The findings may prove useful not only to the Tau Beta Pi Association, but to other nonprofit organizations which conduct direct mail solicitations to raise operating funds.

CHAPTER II

LITERATURE REVIEW

A. Industrial Engineering and Nonprofit Organizations

Many people are unaware of the impact nonprofit organizations have on the economy of the United States. They know that the Red Cross runs blood banks, that churches provide for the spiritual needs of individuals, and that colleges and universities educate the nation's future leaders. But, they do not realize that the budgets of these tax-exempt organizations total billions of dollars.

There are basically two types of nonprofit organizations, self-serving and other-serving.

In self-serving organizations, the beneficiaries pay for the services they are provided. Individuals are free to support and use professional societies, educational institutions, and churches as they see fit. This allows for great diversity in the country's education and religion.

Civic organizations, health causes, and social welfare groups fall into the category of other-serving. Donors are free to support any cause they believe in, rather than having the government dictate which special interests are to receive public funds.

The Internal Revenue Service listed 420,000 churches, 30,000 foundations, and 3,500 private schools as nonprofit organizations in 1972. One-tenth of the nation's service workers get their paychecks from these operations. If one thinks of the number of doctors in nonprofit hospitals and the number of instructors on university payrolls, it is easy to realize that one in six professionals works for a nonprofit organization.[1]

The nation's charitable organizations divided the $39.56 billion in contributions in 1978 as follows: 46.5 percent to religion, 14.0 percent to education, 13.8 percent to health and hospitals, 10.0 percent to social welfare, and 15.7 percent to other groups.[2]

These contributions represented approximately 2.26 percent of the country's disposable personal income in 1978 as compared to 1.96 percent in 1965.[3] This increasing trend will probably continue because many citizens are clamoring for less and less government. Many government services will have to be taken over by nonprofit concerns.

A need exists to critically examine the management of these organizations, since in many cases they are poorly run.

Certainly, there are similarities between profit-making and nonprofit-making organizations' accounting practices, personnel policies and financial concerns. But there are also important differences.

The members of the nonprofit organizations' boards of directors usually come from a wide variety of backgrounds. Some social welfare

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[1] Commission on Private Philanthropy and Public Need, Giving in America, (Washington), p. 11.

[2] Schnaue, op. cit., p. 6.

[3] Ibid., p. 10.

organizations, facing pressure to be more receptive to the needs of their beneficiaries, even have clients (welfare recipients) sitting on their boards. Many of these individuals have to take a "crash course" in management to learn their responsibilities to organizations. Even the more affluent board members, representing the benefactors, find out that nonprofit management is different from the management of their profit-making concerns. Although they do not represent stockholders and do not have a financial stake in their organizations, the directors are obligated, under the laws under which nonprofit organizations are allowed to operate, to answer to the nation's citizenry.

There are a number of differences in financing nonprofit organizations.

Since the income of nonprofit organizations is not taxed, their investments of assets tend to be in high-yielding stocks and bonds, rather than in instruments which have the potential of earning large long-term capital gains. These capital gains are attractive to tax-paying entities since they are taxed at a lower rate than the income derived from interest and dividends.

Nonprofit organizations cannot raise funds by selling stock with the potential to pay dividends because, by definition, any net income they derive "cannot inure to the benefit of any individuals." The traditional engineering economy approaches of solving capital rationing problems by maximizing shareholder wealth, equity, or dividends cannot be used. The discount rate used to evaluate the worth of potential projects and normally computed using the rate of return on equity expected by stockholders and the interest rate on bonds, must be derived by some other means.

Nonprofit organizations are just beginning to look at their productivity. Officials of these groups have scoffed at industrial engineers examining their operations saying that if they were to let an I. E. loose on an orchestra he or she would reduce the number of violinists from 30 to 10, since they are playing the same notes anyway (a good amplification system could make up for the loss in musicians); reduce the number of flourishes in the compositions; and hire trainees who are one-half as good as the current staff of professionals and pay them one-tenth as much.

Poor management is written off as a necessary cost for allowing freedom and fostering diversity, rather than constraining the paid staffs and volunteers of such organizations. Management's number one priority is promoting creativity and caring for the people it serves.

As a result, many managers dislike quantitative measures of their performance. They cannot work with the straightforward objective of maximizing profit, but must turn to elaborate cost-benefit analyses. Management must realize, however, that it must meet the increasing clamor for accountability by attempting to quantify measures of performance. The operations researcher may be called on to derive such measures, just as the National Environmental Policy Act provided for quantification of atmospheric quality through the use of Environmental Impact Units.

Managers are challenged to improve productivity because their organizations are labor-intensive. Whereas 24 percent of the expenses of manufacturing concerns go to labor, 66 percent go to the workers in nonprofit organizations.[4] Manufacturers and other profit-making employers are more likely to be able to adapt new technologies to their companies so their wage increases may be covered by increases in worker productivity.

Nonprofit managers, however, face rising costs because of increased wage demands, which are compounded by the fact that salaries in nonprofit concerns have generally started from a lower base. Workers are demanding wages comparable to their fellows in industry. There are few opportunities to offset these increases through enhanced productivity, however.

If managers cannot improve productivity significantly, they must call upon increased revenues to balance their budgets. Without increased funding, hundreds of colleges, performing arts groups, and civic groups face extinction.

B. Fund-Raising Alternatives

There are a number of ways nonprofit groups obtain funding. Many methods "defy" quantification since they depend on intangibles such as the perceived leadership of organizations or the skill of their grantswriters. There are also some disadvantages in getting funds through these methods.

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[4] Gordon Manser and Rosemary Case, Voluntarism at the Crossroads, (New York: Family Service Association of America, 1976), p. 155.

Obtaining grants has become big business with numerous seminars and periodicals devoted to the subject. The government annually gives over 23 billion dollars to nonprofit organizations in the form of grants.[5] There is some question about researchers' freedom since they are, naturally, reluctant to criticize the government if it funds their research.

Foundation grants represented 5.5 percent of the 39.56 billion dollars contributed by all sources in 1978.[6] The disadvantages of these grants are that since foundations are bombarded with requests for funding, the odds of receiving money are low, and that even if one obtains funds, the grant generally lasts for only one year.

Bequests accounted for 6.6 percent of contributions in 1978.[7] This source of funding cannot be counted as a source of steady immediate income since one has to wait for the donors to begin dying off.

The results of deferred-giving programs may show up immediately or at the time of the donor's death, depending on his or her preference. There are immediate tax advantages to donors who give nonprofit organizations assets to invest, let the organizations keep the annual earnings from them, with the understanding that these assets will be returned to the donor's estate after his or her death. For an immediate sizable tax deduction in the current year one would turn over assets to

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[5]Commission on Private Philanthropy and Public Need, op. cit., p. 16.

[6]Schnaue, op. cit., p. 6.

[7]Ibid., p. 6.

an organization, keep all or a portion of the annual earnings from them, pay tax annually on this yearly income, and let the organization keep the assets after the donor's death. If the total value of the annuity to be paid to the donor is less than the assets' value, the donor is allowed to deduct the difference between the asset value and the annuity from his or her income in the current year. There are even modest annual deductions which may be realized under this latter type of deferred giving.

Universities and hospitals look to capital expansion programs as a "one-shot" source of funds to construct new buildings or build up an endowment. Here again, organizations are dependent on a grants-seeker to identify individuals who are in a position to contribute a large amount of property or securities. In poor economic times, however, donors are reluctant to take as a deduction the depressed market value of the assets. They would rather wait until the price of their stocks rises before making a contribution. Tax regulations favor this, as well, since they allow not only for deductibility of the gift, but an avoidance of the capital gains tax, too. For example, if one donates $1,500 in securities which one originally paid $1,000 for, one may count the $1,500 as a contribution and deduct it and not have to pay taxes on the $500 capital gain.

Five percent of total contributions in 1978 came from corporate gifts.[8] Under an Internal Revenue Service ruling of 1935, up to

[8] Ibid., p. 6.

5 percent of a corporation's profits may be deductible. However, the two billion dollars given in 1978 represented only 1 percent of net income before taxes from the nation's corporations. This proportion has stayed fairly constant for the past 22 years.[9] In fact, only 20 percent of the corporations gave any money at all and only 6 percent of all corporations gave over $500.[10] Most corporations feel that they have no right to disburse their shareholders' profits. They prefer that their shareholders make their own individual decisions on supporting charities.

Even if a nonprofit entity accumulates a sizable amount of assets, it faces problems in investing the sum. Plunging stock prices hurt endowments. Yields on bonds often do not keep up with the rate of inflation. The government has penalized foundations for past abuses by discouraging their formation. Foundations are not totally exempt from taxes because they must pay a 2 percent excise tax on the earnings from their assets.

Where can a nonprofit organization turn for steady annual income? The general public, that's where. Individuals accounted for 83 percent of all charitable contributions in 1978, anyway.[11]

Why do individuals contribute? The major reason, of course, is that they want to share with others. Generosity is a prized human trait.

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[9]Ibid., p. 15.

[10]Commission on Private Philanthropy and Public Need, op. cit., p. 21.

[11]Schnaue, op. cit., p. 6.

But the financial benefits of making contributions seem to be just as important as the philosophic reason of fostering nonprofit organizations' goals. Contributions are deductible from one's income for tax computation purposes, if one itemizes. When the standard deduction is raised, fewer people itemize, so they tend not to "create" extra deductions such as charitable contributions. When the standard deduction was raised in 1974, giving as a percentage of disposable personal income dropped.[12] A survey found that if the charitable deduction were completely eliminated, giving would be reduced 22 percent by those earning between 10 and 15,000 dollars, by 40 percent by those earning between 20 and 30,000 dollars and by 63 percent by those earning between 50 and 100,000 dollars.[13]

The deduction for charitable contributions has been in existence since 1917. Individuals may now deduct up to 50 percent of their income as charitable gifts.

A number of proposals has been offered to liberalize charitable deductions. To encourage giving by individuals in lower tax brackets, 150 percent, say, of the gift could be itemized as a deduction, not just the value of the gift itself. Another suggestion to stimulate giving by low-to-medium income earners, is to allow deductibility for gifts on top of the standard deduction. That is, if the standard deduction is $2,300 and one makes contributions totalling $200 during

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[12] Ibid., P. 10.

[13] Manser, op. cit., p. 118.

the year, the total deductions from income for the year would be $2,500 (the $2,300 standard plus $200 charitable). Although a study has shown that this would result in tax revenue losses of 7.4 billion dollars, it would increase charitable giving by 9.4 billion dollars.[14] The most liberal proposal would allow tax credits for gifts. The total contributions made during the year could be subtracted from one's total tax liability under this scheme.

Just as there are proposals to loosen guidelines, there are others to tighten them. A federal "Truth in Contributions Act," stating that at least 50 percent of an organization's income go to tax-exempt purposes, was considered but turned down by Congress.

Some governments have enacted laws requiring that no more than, say, 25¢ of every dollar raised go to fund-raising administration. The Supreme Court ruled that such laws are unconstitutional because they violated freedom of speech. A governmental unit cannot ban the communications of an organization, including its gift solicitations, according to the Court's ruling in Citizens for a Better Environment vs. Village of Schaumburg, Illinois.

The Internal Revenue Service currently regulates nonprofit organizations through its selectivity in granting tax-exempt status. Individuals are not as likely to contribute to an organization which is not tax exempt because their gifts will not be allowed as deductions. IRS has examined many professional societies such as the American

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[14] Commission on Private Philanthropy and Public Need, op. cit. p. 20.

Chemical Society, questioning their nonprofit status since it believes their primary purpose is to benefit their own members and not the general public. All tax-exempt organizations are eventually accountable to the general public since government revenue is reduced through tax deductions deriving from payments to these groups.

To many association executives, the IRS exists solely to collect taxes and not grant exemptions. To avoid increased government surveillance of their activities, nonprofit organizations have banded together to regulate themselves.

If a citizen asks for an accounting of the activities of a nonprofit concern he or she may call on one of the industry's representatives, the National Information Bureau, the American Association for Fund-Raising Counsel, or the nonprofit section of the Better Business Bureau.

In addition to requiring that annual reports be made available and meetings be open to the general public, a Code of Ethics lists guidelines for conducting fund-raising drives. Those who subscribe to this code will not send unsolicited gifts, such as ties or Indian trinkets, through the mails in return for a contribution. Organizations which use such methods are notorious for spending as little as 10¢ of every dollar raised on charitable purposes, with the remaining 90¢ going to fund-raising administration and the cost of the merchandise. Organizations may not call the general public to solicit funds, under these guidelines. However, a university seeking the support of its own alumni may call them. Professional fund-raisers (of which there are

50,000 in the country today)[15] may not guarantee results or should even promise to raise unobtainable sums of money. They should only work for a fixed fee and never take a percentage of the gross revenues as a commission. Variable fund-raiser fees have led fund-raisers to falsify their reports to receive more income. The fixed fee guidelines are in keeping with the provision that the net income of a nonprofit organization shall not inure to the benefit of an individual.

Given these requirements, what tools are available to nonprofit organizations to raise money annually from individuals?

Door-to-door fund-raising works well only if organizations have large numbers of volunteers to call on their neighbors. The United States Committee for UNICEF enlisted approximately 3,500,000 volunteers in 1978, by far the largest volunteer fund-raising staff in the nation.[16]

Some groups set up donation canisters in markets, but here again, volume is the key. Thousands of stores must agree to put a canister near their cash registers so that a significant sum may be raised. Since stores do not want their checkout areas cluttered with donation containers, groups must compete with one another for the available space.

Selling merchandise has proven profitable to some groups, but the cost per dollar raised is, of necessity, high because the merchandise supplier must be reimbursed for the cost of goods sold. Still, the

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[15] Robert Liston, The Charity Racket, (Nashville: Thomas Nelson, Inc., 1977), p. 54.

[16] Schnaue, op. cit., p. 41.

Girl Scouts received 36 percent of their income in 1978 through their cookie sales.[17]

Direct deductions from worker salaries is the method the United Way used to collect over 1.3 billion dollars in 1978.[18]

Some groups take out paid advertisements to ask for funds. This method has been shown to be productive only if the organization uses a highly-emotional appeal. In most instances, these ads only serve to build up a donor base which may be tapped in future years through direct-mail campaigns.

Telethons have a high public relations value. But even though they attract celebrities like Jerry Lewis and establish themselves, they may still spend 50¢ for every dollar raised on fund-raising.

Some of these methods can be quantified, so that organizations will know approximately how much they should expect to receive. With payroll deductions, for example, if one takes 2 percent from a million dollar payroll one should expect to receive $20,000. But, in general, estimating expected receipts generated through these methods is difficult.

C. Direct Mail Fund-Raising

Another method of fund-raising where the expected results are measurable is direct-mail. Direct mail may be defined as the type of fund-raising where potential donors are solicited for contributions

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[17] Ibid., p. 36.

[18] Ibid., p. 16.

by a letter or other form of communication handled by the Postal Service. Probabilities may be derived for both the percentage response from the total population mailed to and the average gift received. Given these probabilities, one may project expected income.

Direct mail has been a proven success to hundreds of nonprofit entities. After a donor base has been built up through one of the other methods described previously, a direct mail campaign is often used as a follow-up to seek more money. Many public broadcasting stations attract new donors in one year through a telethon and then solicit these new donors the following year using direct mail.

Organizations like to use direct mail to a mass audience because, unlike government or foundation grants, no strings are normally attached to the gifts by the donor. Since the money is not earmarked for a specific purpose, it may be used to cover the day-to-day expenses of running organizations.

Managers have flexibility in the amounts they choose to spend on fund-raising. In times of recession, the size of the mailing list and number of appeals sent to each potential donor may be reduced. The good manager will know which segments of his donors will give in harder economic times so that, say, although total fund raising cost may go down by 25 percent, the total revenue may go down by only 20 percent.

Through the use of computers, segments of the donor universe may be identified and appealed to in different ways; just as a commercial concern will market its product to an upper-class doctor differently than a lower-middle-class laborer. Computer programs generate letters to potential donors which are "personalized" by inserting characteristics of the potential donor, such as the school he or she attended, year of graduation, etc.

Managers may assess the potential contributions by analyzing their data bases of likely contributors. Studies have shown that college graduates give more than people who did not graduate from college, people who live in small towns give more than those who live in big cities, married people give more than single people, old people give more than young people, and, as one might expect, the rich give more than the poor.[19] The wealthy are good targets for a direct mail appeal because it only "costs" someone in the 70 percent income tax bracket $300 to make a $1,000 gift, whereas that same gift would "cost" $860 to someone in the 14 percent tax bracket, thanks to the deductibility of the donations. This is not to say that the poor give much less as a percentage of their income than the upper middle class. In fact, studies done in 1943 and 1962 showed those with incomes of less than $3,000 gave 2 percent of their adjusted gross income to charity as compared with 2.5 percent for those whose incomes were between $25,000 and $49,999.[20] The majority of contributions from the poor went to religious organizations which have found means to handle small gifts economically. Unless managers feel that they could get a significant percentage of the lower income potential donors to contribute their

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[19] Commission on Private Philanthropy and Public Need, op. cit., p. 14.

[20] William Baumol and William G. Bowen, <u>Performing Arts, The Economic Dilemma</u>, (New York: Twentieth Century Fund, 1966), p. 315.

modest amounts, it would not be economically worthwhile to solicit them using direct mail.

Those who are targeted for a direct mail appeal receive letters whose copy is prepared by specialists skilled at making emotional appeals which make the donors feel that they will be doing something worthwhile by making a contribution. Through computerized personalization the copywriters may relate the aims of organizations directly to the donors' own backgrounds and experiences. Since most readers just scan such fund-raising letters it is important to attract their attention by showing that this is not a standard letter going to thousands of people, but a unique one which only that particular reader could have received.

Just as commercial firms test market new products, so do fund-raisers. They will not send an appeal to all of the people on a given mailing list, but will send to, perhaps, 10 percent of them. They will acquire another mailing list and appeal to 10 percent on that one. After test marketing a number of mailing lists, a fund-raiser will use some sort of capital rationing scheme to decide which of the mailing lists sampled should be solicited in their entirety. In general, the decision is made simply on the basis of percentage response or average gift with no consideration given to long-term potential, which an industrial engineer would consider if confronted with a capital budgeting problem.

During this test marketing organizations may find that they will have to improve their public image before mounting any large scale campaign. The March of Dimes proves that the controversy of the cause is a very important public relations tool. It was set up in the 1940's to raise funds to find a cure for polio. Since it could exploit the fact that President Roosevelt had the disease, it was able to raise millions of dollars more than the Heart Fund and other health causes, even though far more people were afflicted with these other diseases than were troubled with polio.

Once these public relations costs are added to the test marketing costs, it is apparent that in the first year of a fund-raising campaign it may cost one dollar to raise one dollar. This is true, however, with sales promotions, as well. A profit-making concern may not begin to show a profit for a year or more while it is building up a loyal clientele.

Fund-raisers take advantage of the fact that an individual donating in year one has made a subconscious commitment to donate in year two. The data base must include information on past gifts so that the personalized letters may remind the donor of the amount he or she gave in the previous campaigns.

In fact, this becomes the major criterion on which to segment the potential donors. A donor who gave more than the average amount receives a different type of appeal than other donors in subsequent campaigns. These donors must be made to feel that their substantial contributions are making an impact. The appeals often take the form of "autotyped" letters, which look as if they were individually typed and have a simulated signature of the letter writer, rather than letters which to most observers may be easily recognized as coming off a computer.

Such special treatment certainly costs more to produce on a per donor basis, but it is in keeping with the marketing philosophy that in order to sell a Cadillac one must spend more per potential buyer than to sell a Chevy, knowing that the profits generated by selling a Cadillac are greater than selling the Chevy. One must keep in mind, however, that many more Chevys are sold than Cadillacs, so the large group of small donors, whose total contributions may exceed the total from the large donors, certainly must not be ignored.

Some Chevy owners eventually become owners of Cadillacs, so fund-raisers realize that they must urge previous donors to upgrade their gifts, at least enough to keep up with the rate of inflation. For example, if an individual gave $10 last year, the letter which he or she receives this year will ask for a gift of $15 or more. The amount one asks for is very important in the text of the letter, since people will tend to give that amount if they feel they are capable of doing so. The upgrading should be realistic; one should not ask a small donor who gave $10 last year to write a check for $100 this year.

Another method of upgrading gift amounts is through the use of special recognition of gifts above certain amounts. Someone who has consistently given $25 per year may be induced to raise his or her gift to $50 by publishing his or her name in a directory of major contributors, which is distributed to other contributors; by listing him or her in an organization's periodical as a major contributor; or by giving him or her a certificate noting something to the effect that he or she is a member of the "Captain's Club" for giving $50 or more. This is in keeping with the basic human need to be recognized for service rendered to others. Some individuals have the time to volunteer to promote the ideals of an organization, whereas others, whose feelings toward the organization are just as strong but do not have the time to volunteer, prefer to make monetary contributions.

Not everyone will give year after year after year. A person who gives one year but fails to give in the next is called a "lapsed" donor. These individuals should not be lumped in the category of individuals who have never given, since studies have shown that many will eventually give again. The text of their letter must remind them that they did show enough interest in the organization at one time to make a contribution and that renewal of their support would be appreciated.

Fund-raisers must make sure donations to organizations are acknowledged shortly after they are received. A fund-raiser sometimes includes other gimmicks in an acknowledgment package to further "butter up" the donor, knowing that once someone gave, he or she is likely to give again.

One way is to insert a "business-reply envelope" along with the thank you letter. (A sender need not affix postage to a business-reply envelope. Postage is charged to the organization by the Postal Service. The organization, thus, only pays for postage on envelopes which come back to it.) It is a subtle method of saying, "If you wish to contribute a bit more this year, we want to make it as easy for you as possible by giving you this envelope to use."

Another way to entice donors is to send a summary of organization achievements during the year, made possible through the contributions. This update, which may take the form of a business letter or newsletter, will keep the organization in the donor's mind, so that, later in the year, when the next appeal is sent, the donor is more likely to give again. This technique need not be used, of course, by organizations which publish periodicals distributed to the donor population.

Once the segmentation has been done, one must decide on fund-raising strategies. A number of questions must be answered.

1. How many appeals should be sent to an individual each year before the fund-raiser admits that he or she will not make a contribution? This is usually a function of the segment of the population one is dealing with. Someone who has never given in the past may only receive one appeal during the year. On the other hand, someone who was a large donor may receive three or more appeals, each different from an earlier one, asking for contributions. The follow-up letters may simply be carbon copies of the previous one with a simulated hand-written note saying that this is a reminder that one did not respond to this letter the first time it was sent out; it is hoped that one will give something this time around. Sometimes the follow-ups are completely new letters containing reasons to give which were not included in earlier letters. It is up to the managers to decide when the cost of the follow-up appeals outweighs the potential revenues they may bring in.

2. What should the appeal's envelope contain? Naturally, it must contain a letter, whose text has been discussed earlier. It should include a response card showing the donor's name, address, and amount given to expedite processing by the fund-raiser. Another must is an envelope addressed to the organization. Often these envelopes are "business reply envelopes." Some organizations, however, put stamps on the addressed envelope. They are essentially paying postage whether the envelope is returned or not, hoping that the recipients will feel obligated to use the envelope by enclosing a contribution in it. Of course, many people will simply steam the stamp off and use it as postage for a personal letter.

Some organizations put copies of newspaper and magazine articles concerning their activities in the appeal package. The donor is made to feel that without his or her gift, word of the organization's good activities might not be spread.

3. When should the appeal go out? Generally the best times to mail are January through May and August through November. During other times of the year many potential donors are taking vacations or enjoying holidays (meaning spending money), and are less likely to give. Many organizations do feel it is worthwhile sending an appeal in December since donors are making preliminary income tax calculations then and may want to increase their charitable deductions by making a gift.

4. Is it profitable to expand the data base for each donor? Recalling the categories of individuals who are more likely to donate

(college graduates, married, etc.), the fund-raiser may ask the donor to provide some personal information. (In fact, if one makes a contribution to a political campaign the Federal Election Commission requires the donor's occupation be given.) This information may be used in future appeals to segment the audience and personalize the letters even more.

These questions face organizations, such as the Tau Beta Pi Association, Inc., as they seek to acquire money to fund their activities.

D. History of Tau Beta Pi Fund-Raising

The purpose of Tau Beta Pi Association, the national engineering honor society, is to promote excellence in engineering by recognizing outstanding academic and professional achievements. Students may be elected to membership if they fall in the top eighth of their junior engineering class or top fifth of their senior or graduate class. Approximately 200 practicing engineers are elected to membership annually as "eminent engineers" based on their accomplishments in business, industry, or academia. The tangible benefits members receive for their initiation fees include a membership key, a membership certificate, and a subscription to the Tau Beta Pi quarterly magazine. Members are also eligible to apply for graduate school fellowships. Most collegiate chapters conduct projects to aid their local campus and community.

The national activities are administered by the headquarters, located in Knoxville, Tennessee. Its budget for the 1979-80 fiscal year was over $3/4 million. An increasing amount of the organization's income is coming through contributions from its alumnus members. Initiation fees from the student members have been providing a smaller proportion of income in recent years. The board of directors' philosophy has been to shift the financial burden of running the organization from the students to the members who have graduated and who, presumably, are in a better financial position to provide operating funds.

In 1966 Tau Beta Pi conducted its first major fund-raising drive, soliciting its alumnus members who had kept up their subscriptions to its quarterly magazine after they graduated. Address labels were produced from Addressograph machine plates used to produce the magazine labels. Other than the printing of the solicitation packet, all fund-raising administration was conducted by the staff of the headquarters. The results of the annual campaigns are tabulated below. In 1972 all membership records were put onto computer files. This gave the organization the opportunity to solicit both subscribers to the magazine and nonsubscribers, who had valid addresses. Those results are shown in Table 1.

The cost per dollar raised in soliciting the subscriber group stayed below 10¢, a very reasonable amount, according to fund-raising guidelines. However, in 1973 and 1974 the solicitations to nonsubscribers actually showed a loss. The costs to solicit these individuals was greater than the amount received from them.

Net income during the period rose from $12,561 in 1966 to $32,717 in 1974. Could the organization do any better?

TABLE 1

RESULTS OF FUND-RAISING CAMPAIGNS CONDUCTED BY THE TAU BETA PI ASSOCIATION FROM 1966 TO 1974

Year	Group Solicited	Direct Expenses	Revenue	Cost per Dollar Raised[1]	Percent of Total Group contributing[1]
1966	Subscribers	$1,174	$13,735	$0.08	3.3
1967	Subscribers	$1,195	$17,508	$0.07	4.1
1968	Subscribers	$1,983	$21,845	$0.09	4.1
1969	Subscribers	$1,881	$28,174	$0.07	5.9
1970	Subscribers	$2,284	$27,199	$0.08	4.8
1971	Subscribers	$2,475	$28,069	$0.09	4.5
1972	Subscribers	$2,456	$29,565	$0.08	4.4
	Nonsubscribers	$2,970	$ 3,557	$0.83	.4
	Total	$5,426	$33,122	$0.14	2.4
1973	Subscribers	$2,830	$34,420	$0.08	4.9
	Nonsubscribers	$2,900	$ 2,106	$1.38	.4
	Total	$5,731	$36,526	$0.16	2.9
1974	Subscribers	$3,504	$37,880	$0.09	5.6
	Nonsubscribers	$3,566	$ 2,107	$1.69	.3
	Total	$7,070	$39,987	$0.18	3.1

[1]Weighted average for Total in 1972, 1973, and 1974 Cost per Dollar Raised = Revenue/Direct Expenses.

Source: Supporting documents from Tau Beta Pi Annual Reports.

Epsilon Data Management (Epsilon) had offered proposals for a number of years to increase the net income. Its 1974 version was accepted by the board of directors.

Epsilon, founded in 1969, provides computerized record keeping, information management consultation, and direct mail research and evaluation to over 200 organizations, including the Boston Symphony, the World Wildlife Fund and the Zoological Society of San Diego.

Epsilon believed that in its first year of handling Tau Beta Pi's fund-raising it could raise $103,500, spending $32,800 on administration of the program (including approximately $8,000 in costs incurred in processing returns at the Tau Beta Pi headquarters). In the previous year Tau Beta Pi had netted $32,000. Epsilon said that its costs would be over $32,000. What could Epsilon provide that Tau Beta Pi could not provide by spending $7,000 on administration?

Epsilon outlined four unique features of its program:

1. Establish a "credible correspondence relationship in copy" to the individual donors by personalizing each letter, using the association's basic computer membership data base (name, address, chapter the person is a member of, year of graduation, and whether the person had a magazine subscription), and supplementing this with information on previous donations. Under the Tau Beta Pi headquarters' administration, all members received identical solicitation packages.

2. Ask for a specific gift amount, according to the individual's previous giving pattern. Under the Tau Beta Pi administration all members were asked to give the same suggested amount, regardless of

whether they had given $100 consistently over the preceding six years or had never given.

3. Mail as often as possible to maximize the long-term revenue accruing to the organization. Under the Tau Beta Pi administration, no follow-up mailings were made. Epsilon felt it was worthwhile mailing two to three solicitations to an individual before admitting that he or she would not give that year. Epsilon would mail to all members who had a valid address on the records, subscriber and nonsubscriber alike, just as the Tau Beta Pi headquarters had in 1972-74.

4. Make a special appeal to major contributors through the use of "autotyped" letters and first class postage on the envelopes, using commemorative stamps, rather than producing a letter with a computer typeface and sending the envelope by third class bulk mail. Under the Tau Beta Pi administration, all envelopes were sent out by third class bulk mail.

The board of directors' commitment was made, the materials prepared, the envelopes mailed, and the association's officers waited to see if they could, in fact, at least break even.

During that first year, $159,806 was raised. Costs rose too, however, reaching $50,205 for administration both by Epsilon and the headquarters of Tau Beta Pi, which processed all of the returns. That, still, represented a net income of $109,601, over three times the amount netted in the previous year. The percent of those solicited who responded also tripled, from 3.1 percent to 10.9 percent.

Some association officials wondered if this would be a one-year phenomenon. They believed that the members may think that this was a special one-time effort and that the organization could not hope to raise as much money in future years. They did not recognize the fund-raising principle mentioned earlier that most people develop the habit of giving annually to a cause they believe in, if they are asked to.

The results of the 1975-1979 campaigns follow in Table 2.

TABLE 2

RESULTS OF FUND-RAISING CAMPAIGNS CONDUCTED BY THE TAU BETA PI ASSOCIATION FROM 1975-1979

Year	Direct Expenses	Revenue	Cost per Dollar Raised	Percent of Total Group Contributing
1975	$50,205	$159,806	$0.31	10.9
1976	$60,379	$182,779	$0.33	9.8
1977	$85,001	$260,501	$0.33	13.4
1978	$63,341	$247,693	$0.26	14.0
1979	$80,178	$273,934	$0.29	12.9

Source: Supporting documents from Tau Beta Pi Annual Reports.

Those individuals who had given for the first time in 1975 did give again in 1976, and new donors were attracted, not only in 1976, but in subsequent years as well.

The solicitation "strategy" was modified slightly for each of the annual campaigns, as Epsilon's and the headquarters' knowledge grew about the donor base. For example, in 1975 and 1976 all members for whom the association had good addresses were solicited. This included members in the "nondonor/nonsubscriber" category, composed of individuals who had not contributed in earlier appeals nor had maintained their subscription to the association's quarterly magazine. Only 2-4 percent of this group contributed in these years as compared to approximately 75 percent in the Major Donor category, consisting of members who contributed more than $25 (this minimum amount was later raised to $50). Epsilon and headquarters decided that, starting in 1977, all 48,000 members who were in the nondonor/nonsubscriber category would not be solicited but only approximately 32,000 per year. Deleting 16,000 individuals whose probability of giving was minuscule, was the major reason the percentage of the total group contributing rose from 9.8 percent to 13.4 percent from 1976 to 1977.

Both Epsilon and headquarters have compiled statistics on aggregate donations. In Epsilon's budget proposals for a forthcoming year, one sees predictions that, say, 75 percent of the 1,000 Major Donors last year will give again this year an average of $75 each. These forecasts have, in general, proven correct and in many cases, fortunately for Tau Beta Pi, have actually underestimated revenue.

However, neither Epsilon nor the headquarters has examined the behavior of the individual donors to see if the average one gives year after year, "lapses" every so often by not giving every few years, or consistently upgrades his or her gift each year.

Markov chain analysis is used in this paper to model this behavior. The giving pattern which is described through the Markov chain should prove valuable not only in gaining insights into the behavior of the average donor, but also help in making forecasts of future revenue. Markovian decision models will be derived to help Epsilon and the headquarters plot their fund-raising strategies for forthcoming years.

E. Markov Chain Theory

Markov chains are a convenient means to describe movements of entities from one characteristic or state to another.

A system may be modelled using a Markov chain if three basic conditions are met.

First, the process must have a finite number of states. The choice of these states is crucial.

Second, the probability of being in a given state does not depend on time, only on the previous state one was in. If the next state were not dependent on the previous one, the exercise would simply be to derive a probability density function for each of the ending states, ignoring any previous behavior.

Finally, the probability must be invariant through time. This is a difficult requirement to adhere to when used in describing human behavior because, as time goes on, the subjects of the experiment grow older. Their personal traits, such as income will vary over the years.

In order to obtain the parameters of the model one must have the behavior patterns of individuals at each time period. Approximations may be obtained using aggregate time series data which give the frequency of being in a cell,[21] but the analysis is simpler and statistically sounder if "micro" data exist.

The key pieces of micro data are the n_{ij}'s the number going from state i in time t to state j in time t + 1. Anderson and Goodman showed that these n_{ij}'s are sufficient statistics.[22]

They also showed that the maximum likelihood estimator for the probability of movement between state i and state j was $n_{ij}/\sum_i n_{ij}$.

To prove that the parameters fit the Markov model, Anderson and Goodman suggested two tests. One, the likelihood ratio test is seldom cited in the literature on Markov chains because of its mathematical complexity. The other is a chi-square test which they proved to be asymptotically equivalent to the likelihood ratio test.

Goodman refined this test in a later paper.[23] His updated method uses the statistic

$$\chi^2_{(r-1)(c-1)} = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(n_{ij} - \varepsilon_{ij})^2}{\varepsilon_{ij}} \tag{1}$$

where n_{ij}, is the observed number in cell ij and ε_{ij} the expected number in the ijth cell, found from:

$$\varepsilon_{ij} = \frac{1}{\sum_{i=1}^{r} \sum_{j=1}^{c} n_{ij}} \sum_{j=1}^{c} n_{ij} \sum_{i=1}^{r} n_{ij} \tag{2}$$

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[21] T. C. Lee, G. G. Judge, and A. Zellner, Estimating the Parameters of the Markov Probability Model from Aggregate Time Series Data. (Amsterdam: North Holland Publishing Co., 1977).

[22] T. W. Anderson and Leo A. Goodman, "Statistical Inference about Markov Chains," Annals of Mathematical Statistics, vol. 28, 1957, pp. 89-110.

[23] Leo A. Goodman, "Statistical Methods for Analyzing Processes of Change," The American Journal of Sociology, vol. 68, July 1962, pp. 57-78.

Researchers will usually first show in their papers that the Markov chain does exist.

The next test deals with "stationarity"; do the p_{ij} for a given state i remain the same from year to year? A contingency table is set up with rows made up of n_{ij} values for time t to t + 1, time t + 1 to t + 2, etc. A chi-square value is calculated. If it is less than the table of chi-square's percentage point's value for the given level of confidence and number of degrees of freedom, the process is stationary.

The final test is "homogeneity." For a given year, do all participants in the experiment exhibit the same p_{ij}'s? To prove this the sample is broken down according to some characteristic(s) and a chi-square test run on the n_{ij}'s which result from the breakdown.

Among the facts which may be derived once the Markov chain has been found are the first passage time and the state occupancy. The former value tells how long it will take to go from state i to state j for the first time, while the latter shows how much time an individual spends in a given state.

F. Markov Decision Theory

The solution to the problem of selecting the optimum alternatives is based on Howard's Value Iteration—Policy Improvement algorithm using discounting.

The method computes the present value of a series of yearly cash flows, representing the differences between the revenues and costs for each year. The discount rate reflects the uncertainty of future income and costs.

A computer program based on Howard's algorithm was written and is shown in the Appendix. It is based on the following:

Given that:

p_{ij}^{k} — probability of going from state i to state j under option k

r_{ij}^{k} — reward for going from state i to state j under option k

v_j — value of ending in state j

D — discount factor

one uses the following equation:

$$v_i = \sum_{j=1}^{N} p_{ij}^{k}(r_{ij}^{k} + Dv_j) \qquad i = 1, 2 \ldots N \tag{3}$$

to solve for the values of v given that option k is in effect. The sum of the products, $\sum_{j=1}^{N} p_{ij}^{k}\, r_{ij}^{k}$, is constant for each i and each k throughout the iteration process and may simply be called q_i^k, the expected immediate reward. The solution of the N equations above with N unknowns, v_1, $v_2 \ldots v_N$, constitutes the Value Determination portion of the algorithm.

The Policy Improvement routine uses these values for the v_j's in the following test quantity:

$$q_i^k + \left(\sum_{j=1}^{N} p_{ij}^{k}\, v_j\right) D \tag{4}$$

This formula states that one must choose from among the options represented by the superscript k, the one which maximizes the test quantity, which is the present value of being in state i. The quantity q_i is the expected immediate reward which accrues once one leaves state i and the quantity $D\left(\sum_{j=1}^{N} p_{ij}^{k}\, v_j\right)$ is the expected value resulting from transitions into state i from the various states j, discounted by the factor D. The set of optimum alternatives determines the "policy" for that iteration.

The values of p_{ij} and q_i associated with the optimum alternatives for each state i are then substituted into the value determination equation (3) and the cycle continues. When the policies for two successive iterations are the same, the routine ends and that policy is the long-term strategy which should be followed.

To begin the process, one substitutes into the Value Determination formula the values of q_i and p_{ij} which are associated with the maximum expected immediate reward for being in state i. The initial values of $v_1, v_2 \ldots v_N$ are set equal to zero.

After the optimum policy is found one may conduct sensitivity analyses on the discount factor and the parameters of the transition probability and reward vectors.

G. Applications of Markov Chain Theory

The fund-raising problem is essentially a marketing dilemma. Just as Proctor and Gamble spends millions of dollars researching how to get housewives to "Trust Their Clothes to Tide," fund-raisers must analyze their audiences. When a new product is introduced, much money goes into promoting it through advertising, meaning that it may take years to recoup the investment. The result of this promotion, one hopes, is a loyal consumer group which will purchase the product over and over again. A fund-raiser may have to spend 50¢ on administration for every dollar raised in the first years of solicitation in order to build up a donor base. One hopes that the fund-raiser is building up a loyal following which will contribute over and over again, thus recouping the initial fund-raising investment, and bringing fund-raising administration costs down to an acceptable level.

Quantitative methods, particularly statistics, are the backbone to modern marketing. Montgomery and Urban detailed three common mathematical techniques used to describe consumer behavior.[24] The first, called "Zero-Order," states that consumer behavior is independent of past actions. Since consumers are "memoryless" analysts may use probability distributions to model consumer actions. The "Learning Curve" approach states that consumers do rely on past information to make their decisions. Regressions are run to fit the probability of purchasing an item against a measure of the consumer's knowledge of it.

The other method making use of past behavior to describe current actions is Markov chain analysis. Styan and Smith quantified housewives' behavior in laundry-product purchases using four states in the system: buy detergent only, buy soap powder only, buy both products, buy neither product.[25] The tests showed the actions could be described by a first-order homogeneous chain.

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[24] David Montgomery and Glenn L. Urban, Management Science in Marketing, (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1969).

[25] George P. H. Styan and Harry Smith, "Markov Chains Applied to Marketing," Journal of Marketing Research, vol. 1, no. 1, pp. 50-55.

Lipstein also published a paper on laundry-product purchases, but went beyond the mere description of the process.[26] He considered the effectiveness of test marketing a new brand. He questioned the length of time taken to test market in order to reach a decision on whether a new brand should be introduced to the entire market. He believed that the decision-making time could be shortened by using Markov chains.

Given are two Markov chain matrices which model switching between brands and sticking with the same brand, immediately preceding the introduction of the new brand to the system. If these two matrices, call them R_o and R_1, were essentially identical, the market would be stable, $R_oC = R_1$, where C would approximately be an identity matrix. If the matrix describing behavior is derived after the new product is introduced, R_2, is approximately the same as R_1; the new product has not made much impact on the market and the promoter should consider a new strategy for selling the product. However, if R_2 is different from R_1 then the causitive matrix, C, in the equation $R_1C = R_2$, is not similar to the identity matrix, indicating that the market is undergoing perturbations. Lipstein chose to look at C's eigenvectors as the measure of market stability. If these eigenvectors are close to 1, as in the case, of course, for a matrix similar to an identity matrix, the market is stable. If they are greater than 1, there is divergence, indicating that the new brand may be picking up a loyal consumer

[26]Benjamin Lipstein, "Test Marketing: A Perturbation in the Market Place," Management Science, vol. 14, no. 8, April 1968, pp. B437-448.

following. Examining these C's, the causitive matrices for the first few time periods of the test marketing, proved to be an effective means of evaluating the impact of a new product, and led to decisions being made earlier than had been made before. Specifically, Lipstein found that it was harder to make inroads in laundry detergent purchasing since 80 percent of the consumers bought the same brand consistently, as compared to soap powder purchasing where only 50 percent buy the same brand time after time.

Even an institution many consider a stable element of a community, the local newspaper, is subject to fluctuations in readership, as Deming and Glasser found out.[27] They discovered that through Markovian analysis they could answer many of management's questions concerning subscriptions, which had previously been answered through speculation and guessing. They directed the newspaper's marketing efforts toward segments of the population which had historically renewed their subscriptions, keeping a struggling newspaper from folding.

The applications of operations research are by no means restricted to marketing. Corporate finance departments have recognized its value, as well.

Sibley analyzed corporate bond yields, studying the risk characteristics of short- and long-term yields through Markov chains.[28]

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[27] W. E. Deming and G. J. Glasser, "A Markovian Analysis of Newspaper Subscriptions," Management Science, vol. 14, no. 6, February 1968, pp. B283-290.

[28] A. M. Sibley, "A Markov Model of Corporate Bond Yields," Review of Business and Economic Research, vol. 12, no. 2, Winter 1976-77, pp. 1-16.

The other major area of the capital market, stocks, was considered by Fielitz and Bhargava.[29] They tested the movements of the day-to-day prices of 200 stocks. Unfortunately, they did not find the key to making a killing in the market. Their model proved to be nonhomogeneous; while an individual company's stock may generally follow a trend in the market, its own price behavior depends mostly on how the stockholders view the company's worth, a factor which is difficult to quantify. They aggregated the 200 stocks into one chain thinking that they might view a trend. Here again, no luck in finding the Market Minerva since with the market going up and down over time the results, naturally, yielded nonstationary chains.

Even personnel managers have investigated Markov chains. Stewman looked at manpower planning by modelling movement among the ranks of one state's police force.[30] He set up a chain whose states were patrolman, sergeant, lieutenant, etc. One factor proved to make the Markov model invalid—the movement upward depended on loss rates out of the upper states, which rates were not constant. In the other applications reviewed for this study nothing constrained movement into a state. In this case, however, since there were a limited number of positions in the upper ranks a subordinate could not move up at will. He or she had to wait for an opening. Stewman decided that a "renewal model," as he

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[29] Bruce D. Fielitz and T. N. Bhargava, "The Behavior of Stock Price Relatives," Operations Research, vol. 21, no. 6, November 1973, pp. 1183-1199.

[30] Shelby Stewman, "Markov and Renewal Models for Total Management Systems," Omega, vol. 6, no. 4, 1978, pp. 341-352.

called it, using formulas describing the loss rates out of the upper states, was the proper method to use, rather than a Markov model.

Since probability practitioners owe much of their existence to gambling, it seems only proper that some have paid tribute to sports wagering by writing papers on the applications of Markov chains to athletics. Kemeny and Snell enumerated the probabilities of winning a game in tennis, given that one wins a game by getting at least four points and winning by a margin of two points and given one knows the probability of winning a single point at any time.[31]

Alas, the money wagered on tennis is a pittance compared to that of football, so their article could not have attracted the attention that Silverman and Schwartz's "How to Win by Losing," dealing with pro football, did.[32] They used Markov analysis to show that under the "wild-card" system of selecting playoff teams, it may actually be advantageous for a team to purposely lose a game in order to face an opponent in the opening playoff that it has a better chance of defeating.

Social scientists have used Markov chains to analyze human behavior. Goodman examined voter preference during a presidential campaign with Markov chains, using the states of Democrat, Republican and Undecided.[33]

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[31] John G. Kemeny and J. L. Snell, Finite Markov Chains, (Princeton, New Jersey: Van Nostrand, 1960), p. 161.

[32] David Silverman and Benjamin J. Schwartz, "How to Win by Losing," Operations Research, vol. 21, no. 2, March 1973, pp. 639-643.

[33] Leo A. Goodman, "Statistical Methods for Analyzing Processes of Change," The American Journal of Sociology, vol. 68, July 1962, pp. 57-78.

Among the conclusions drawn was that the chains were not stationary. Voters were quicker to change preferences immediately after a party convention than at other times during the campaign. The population's behavior was not homogeneous as voters, stratified according to their interest in politics, were modelled by different chains, as were voters from various racial and educational backgrounds. The results of the polls during the campaigns did not take into account a significant factor which discredited their validity in predicting the actual outcome of the election, not all of those polled actually voted. Since a higher proportion of those responding "Republican" actually voted, the pre-election polls showed more "Democrat" strength than was actually realized at the voting booths.

Mobility of the population both in terms of geographic changes and social strata changes are suitable for quantification through Markov chains. Collins wrote a book educating the geographer on possible applications of Markov chains.[34] One of several articles written on social mobility concerned educational aspirations. Its author, Kayser, showed how an individual's current goals related to his or her earlier objectives.[35]

Whereas Kayser looked at the entire population of a school, Anderson modelled the educational goals of an elite segment of it,

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[34] Lyndhurst Collins, Introduction to Markov Chain Analysis, (London: Geography Abstracts Ltd., 1975).

[35] Brian D. Kayser, "Educational Aspirations as a Markovian Process," Journal of Mathematical Sociology, vol. 4, 1974, pp. 295-306.

medical school students considered attending first years of medical school.[36] The states of his system were the various medical speciality choices, general practice, surgery, etc. His testing showed the Markov chain was first-order and stationary. There were a few time periods in this discrete-time model when the stationary chain did not hold because the students made more switches than between the normal time periods. His original model of 6 states was collapsed into 3 states and the hypotheses remained valid.

Markov chains have been used in medicine itself. Schactman and Hague investigated events followed induced abortion.[37] To assure homogeneity of their sample, they looked at patients from a given town being served by a clinic. The Markov chain's states included susceptibility to pregnancy, spontaneous abortion, premature delivery, normal delivery, and mature delivery. Their paper quantified the long-term repercussions of having an induced abortion.

Meredith offered two papers in this area. His first concerned patients' progress through a geriatric ward's rehabilitation stations. He modelled the length of time patients stayed in the hospital before being released to their homes (or to their morticians). He decided not to include the death state in his final model because it affected its stationary nature. As a patient gets older the probability of dying increases, so the matrix components would change over time. He

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[36] R. Bruce Anderson, "A Markov Chain Model of Medical Specialty Choice," Journal of Mathematical Sociology, vol. 3, 1974, pp. 259-274.

[37] Robert Schactman and Carol L. Hague, "Markov Model for Events Following Induced Abortion," Operations Research, vol. 24, no. 5, September 1976, pp. 916-932.

rationalized that since the probability of dying was so low in the patients he observed, leaving this death state out of the model would not seriously affect it. Given the stationary matrix, he was able to derive the long range distribution vector, which gave the probability of being in each state. He obtained the expected cost for the system by multiplying this vector of probabilities by the cost of being in each state.[38]

His second article also went beyond the mere description of behavior by including concepts of decision theory.[39] He took the engineering economist's approach to cost accounting and applied it to selecting an optimal training program for the mentally retarded.

Each patient's state was determined by his or her level of ability to perform various tasks. Each patient was assigned a score of 1.0 to 4.0 (4.0 being the highest ability level) with the eight states of the system consisting of the intervals 1.0 to 1.5, 1.5 to 2.0, etc. A patient moved among these states from one time period to another by participating in one of five programs, including behavior modification and intensive training. Some of these programs were only available to those with higher ability levels (those in states "3.0 - 3.5" and "3.5 - 4.0"). An attempt was made to quantify the benefits derived from moving from one state to another, so that a net benefit score (benefits

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[38] Jack Meredith, "A Markovian Analysis of a Geriatric Ward," Management Science, vol. 19, no. 6, February 1973, pp. 604-612.

[39] Jack Meredith, "Selecting Optimal Training Programs in a Hospital for the Mentally Retarded," Operations Research, vol. 24, no. 5, September 1976, pp. 899-915.

minus cost) could be assigned to each matrix cell, in addition to the probability of moving from one state to the other, under each program. To assure homogeneity, patients of a similar age and IQ range were selected for the study.

The chain proved to be first order because the patients forgot skills learned in earlier time periods rapidly. That is, the state in time period t-2 had little effect on the state they were in at time period t.

Based on this chain, Meredith derived a decision model using discounting. Using Howard's value iteration algorithm, he recommended the programs which should be used at the different ability levels.

Realizing that this optimum policy may not be economically feasible, he obtained another strategy with cost constraints. He solved the constrained problem by simply dropping one of the policies from the solution and resolving the problem. No mathematical optimization was attempted, because of the complexity of integrating the value iteration algorithm into the optimization.

F. F. Sokkar analyzed the admission of new students as a Markov chain.[40] He followed students as they entered the university, progressed in its programs, and exited from it. His model was first-order, nonstationary, and had two absorbing states, graduation or drop-out.

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[40] F. F. Sokkar, "A Markov Model for Admissions of New Students: A Theoretical Study," (Urbana, Illinois: Dissertation, University of Illinois, 1971).

He showed that universities could base their admission quotas, allocate their limited resources, and predict the number of graduates from their programs of study from the Markov chain model. The Markov chain statistics were incorporated into a goal programming formulation. The objective was to minimize the difference between the targeted number of degrees awarded from the various programs of study and the actual number of degrees granted. The constraints were the number of applicants coming into the university either at the freshman level or through transfer from other schools (both were described by statistical distributions), the enrollment ceiling, and the availability of both physical facilities and physical bodies (that is, the number of instructors available in the various departments).

CHAPTER III

ANALYSIS OF TAU BETA PI FUND-RAISING FROM 1972 TO 1979

A. Hypothesis Testing

A number of statistical tests may be run to prove that a process can be described by a Markov chain. Three of them were applied to the data from Tau Beta Pi's campaigns conducted from 1972 through 1979; order, homogeneity and stationarity.

A sample of 2,100 members was taken from the list of 20,181 individuals who had contributed to Tau Beta Pi at least once between 1972 and 1979. The sample was chosen on the basis of the random code assigned to each member, a letter between "A" and "Z." A member became part of the sample if his or her code letter was a "B," "G," "P," or "X," letters which were chosen at random, and his or her last name began with a letter between "A" and "P."

Each member's year of graduation, date(s), and amount(s) of gifts made were punched into a computer card. If the member died or was removed from the mailing list because of a bad address the date of that event was also recorded.

A computer program, shown in the appendix, computed the elements of three different sets of matrices, based on the giving records of 2,100 members in the sample.

One set of matrices shows the number of members going from one state of the system to another for each of the possible years of transition, 1972 to 1973, 1973 to 1974 . . . 1978 to 1979. Given these numbers, a set of matrices of transition probabilities was computed.

The third set of matrices computed shows the average gift size for members entering the Major Donor, First-time Donor, and Renewed Donor states. For example, one may find the average gift a Non-Donor made in 1974 in order to enter the First-time Donor state. This information was needed to compute the components of the reward vectors of the Markov chain.

The transition matrices of the absolute numbers going from one state to another were analyzed using the Chi-square test for contingency tables described earlier. The results were obtained from a computer program shown in the appendix.

All members who graduated in 1971 or earlier first occupied the New Member state. Thereafter, a member who graduated entered the system the year after graduation. So, for example, one who graduated in 1976 made a transition from the New Member state to another state in the period 1976 to 1977, based on his or her action in 1977. If that 1976 graduate made a $25 contribution in 1977, the transition would be from New Member to First-time Donor.

The Lapsed Major, Lapsed Donor, and Renewed Donor states were not reachable until 1973. A member could not enter one of these states until he or she had occupied either the First-time Donor or Major Donor state. The first year these two states could be occupied was 1972.

Because of the nature of the data, the tabulations for the Non-Donor and New Member states were not analyzed for each transition.

Since all members in this sample eventually became contributors, all left the Non-Donor or New Member state at some time. In actual practice, of course, many members entered the Non-Donor state and stayed in it until they died or until a bad address was reported for them.

Similarly, for the last year, 1979, all graduates of the class of 1978 in order to be considered for this analysis, must have contributed in 1979. Since all New Members became First-time Donors the probability of entering the Non-Donor state from the New Member state in 1978 was zero. No analysis was conducted on the Dead or Lost state because once it is entered, it was assumed that it could never be left.

Hence, the historical analysis focused on the behavior of those who had made at least one donation.

The tables below show that the process was not zero-order. The system had been simplified to three states, donor, not-donor, and dead or lost. That is, of the original eight states in the system, three were considered as donor states (Major Donor, First-time Donor, and Renewed Donor), four constituted the not-donor (Lapsed Major, Lapsed Donor, Non-Donor and New Member), and one retained its original definition (Dead or Lost). The tabulations obtained from the computer analysis of the sample of 2,100 were translated into the three states from the original eight. Table 3 is a typical table. A chi-square test was run on this matrix. Since the Dead or Lost beginning state contributed no "knowledge" to the system, the number of degrees of freedom was calculated based on the two beginning states, Donor and

Not-donor, and the three ending states, Donor, Not-donor, and Dead or Lost. The total number of degrees of freedom was 2.

TABLE 3

NUMBER OF MEMBERS MOVING FROM ONE STATE IN 1978 TO ANOTHER IN 1979

From/to	Donor	Not-Donor	Dead or Lost
Donor	760	294	17
Not-Donor	340	613	17

The Chi-square values for the table above and the results for the preceding 5 years are shown in Table 4:

TABLE 4

VALUES OF CHI-SQUARE STATISTICS COMPARING DONOR AND NOT-DONOR BEHAVIOR

Years of Transition	Chi-Square Statistic
1973 to 1974	372.78
1974 to 1975	68.59
1975 to 1976	25.17
1976 to 1977	201.94
1977 to 1978	217.68
1978 to 1979	268.22

The large values of the statistics mean that the hypothesis that the state in time $t + 1$ was independent of the state in time t can be rejected at the .01 level.

To obtain data for the homogeneity of the system the sample was broken into four categories, graduates from the classes of 1900-1946, graduates of 1947-1960, graduates of 1961-1971, and graduates of 1972-1978. The cutoffs were chosen so that approximately one-fourth of the sample was included in each category.

A sample tabulation of those leaving the Donor and Not-donor categories is shown in Table 5.

TABLE 5

ANALYSIS OF DONOR AND NOT-DONOR BEHAVIOR FROM 1978 TO 1979

Leaving the donor state				Leaving the not-donor state			
Graduation Year	donor	New state not-donor	dead	Graduation Year	donor	New state not-donor	dead
1900-46	213	49	9	1900-46	62	132	2
1947-60	222	59	2	1947-60	60	135	2
1961-71	175	96	1	1961-71	77	183	5
1972-78	150	90	5	1972-78	141	163	8

The Chi-square values for the tables above and the results for the preceding 5 years of transition are shown in Table 6.

Although some values do fall below the Chi-square point of 12.6 (for 6 degrees of freedom, assuming a .05 level of significance), one may conclude that the sample as a whole was not homogeneous. One must use caution in Markov analysis with human subjects because their behavior is likely to change because of personal traits, such as aging and income level. An analysis of the year-by-year statistics showed that those from the earlier graduation years were more likely to stay in the Donor category and more likely to move out of the Not-donor category than those from later graduation years. Graduation year may thus be a worthwhile variable upon which to segment the audience of past and potential donors.

TABLE 6

VALUES OF CHI-SQUARE STATISTICS COMPARING DONOR AND NOT-DONOR BEHAVIOR FROM SETS OF GRADUATION YEARS

Leaving the donor state		Leaving the not-donor state	
Years of transition	Chi-square value	Years of transition	Chi-square value
1973-1974	14.43	1973-1974	8.34
1974-1975	21.11	1974-1975	5.25
1975-1976	10.81	1975-1976	18.85
1976-1977	21.11	1976-1977	13.87
1977-1978	34.78	1977-1978	14.36
1978-1979	45.74	1978-1979	24.90

The next measure was the stationarity of the process. The analysis lumped the four graduation categories into one, meaning that homogeneity for the sample was assumed. The question answered was, "Does the behavior of Donors and Not-donors vary over time, or it it constant?" The table below shows the number in the sample making transitions from one state to another (Table 7).

The Chi-square statistic for the Donor state was 155.32, while the Chi-square statistic for the Not-donor state was 1131.17. One could reject the hypothesis that during the years 1972 to 1979 the behavior was stationary. This, however, could be expected because different techniques were used to solicit funds and the results, in terms of the percentage responding, were different. The Donor and Not-donor behavior for 1972 to 1973 and 1973 to 1974, years when Tau Beta Pi conducted its own fund-raising, yielded Chi-square statistics of .572 and .0004, respectively. The hypothesis of stationarity may be accepted at the .05 level.

TABLE 7

NUMBER OF MEMBERS LEAVING THE DONOR AND NOT-DONOR STATES

Leaving the donor state				Leaving the not-donor state			
Transition Years	New state donor	not-donor	dead	Transition Years	New state donor	not-donor	dead
1972-1973	103	96	3	1972-1973	106	1324	0
1973-1974	116	97	2	1973-1974	112	1403	0
1974-1975	165	60	3	1974-1975	754	850	1
1975-1976	469	440	10	1975-1976	398	587	6
1976-1977	588	278	1	1976-1977	391	697	9
1977-1978	684	287	8	1977-1978	387	643	12
1978-1979	760	294	17	1978-1979	340	613	17

The transition matrix was unstable from 1974 to 1976. These were the years when Epsilon's techniques first began to have their effect. One may say that the causitive matrix, C, in the matrix equation $R_1 = R_0C$, explained earlier in the literature review section, did not resemble the identity matrix.

In 1977, however, Epsilon's methods were starting to wear in. The Chi-square statistic for Not-donor behavior for the years 1976-1977, 1977-1978, and 1978-1979 was 4.09, which, for 4 degrees of freedom, means that one may accept the hypothesis of stationarity at the .05 level. The Chi-square value for the Donor state, given that there are three states one may enter, was 15.89, meaning that stationarity cannot be accepted. However, the number entering the Dead or Lost state varied widely during these three years, greatly increasing the Chi-square statistic. If the Dead or Lost state were combined with the Not-donor state meaning that there were only two states which may be entered from the Donor state (Donor and the combined Not-donor—Dead or Lost state) then the Chi-square statistic would be 2.27. Given 2 degrees of freedom, the hypothesis may be accepted at the .05 level of significance. One may conclude that if two states were used to describe the system and the fund-raising strategy used is constant (either the Tau Beta Pi approach used in 1972-1974 or the Epsilon method of 1976-1979), then the process is stationary.

The next problem was to examine the stationarity using all of the states which Epsilon used to segment members. Table 8 below shows the number leaving the Major Donor state and entering one of the four states which may be reached from the Major Donor state.

The Chi-square statistic for the seven years of transition was 21.88. For 18 degrees of freedom, the hypothesis of stationarity may be accepted at the .05 level.

A similar analysis of Lapsed Major behavior from 1973 to 1979 (there were no Lapsed Majors in 1972 for the sample because the lapsed state was not reachable until a year had transpired) yielded a

Chi-square statistic of 21.04 which also means that the hypothesis of stationarity may be accepted.

TABLE 8

NUMBER OF MEMBERS LEAVING THE MAJOR DONOR STATE OVER TIME

Transition Years	Major Donor	Lapsed Major	Renewed Donor	Dead or Lost
1972-73	4	3	1	0
1973-74	2	6	1	0
1974-75	6	1	0	0
1975-76	32	17	1	2
1976-77	46	15	1	1
1977-78	62	17	4	2
1978-79	70	17	4	2

The behavior of these Major Donors and Lapsed Majors appeared to be invariant over fund-raising strategies. The number of Major Donors in the Tau Beta Pi program was small in comparison to that under Epsilon's. If one examined the last four transitions, where Epsilon's services were used, the Chi-square statistics would be 6.60 and 12.98 for Major Donor and Lapsed Major behavior, respectively. Both are acceptable at the .05 level for 9 degrees of freedom.

The same stability could not be shown for the other categories however. Table 9 below shows the Chi-square statistics obtained for the states, the transition periods analyzed, and their levels of significance.

These values prove that stationarity did not exist during the period from 1972-1979. The table also shows that stationarity did not

TABLE 9

ANALYSIS OF CHI-SQUARE STATISTICS FOR STATIONARITY OF STATES OF THE SYSTEM

Transition Period	No. Degrees of Freedom	Chi-square Statistic	Accept at .05 Level?	Accept at .01 Level?
		Leaving the First-time Donor State		
1972-1979	18	43.44	no	no
1975-1979	9	30.89	no	no
1975-1978	6	16.15	no	yes
		Leaving the Lapsed Donor State		
1973-1979	15	93.7	no	no
1975-1979	9	47.3	no	no
1975-1978	6	24.9	no	no
		Leaving the New Member State		
1972-1978	15	83.4	no	no
1975-1978	6	18.2	no	no
		Leaving the Renewed Donor State		
1973-1978	15	49.9	no	no
1975-1979	9	40.2	no	no
1975-1978	6	12.4	yes	yes

hold during the 1975-1979 period of Epsilon's efforts. When the last transition year 1978-79 was removed from the analysis stationarity may be accepted at the .01 level for the Renewed Donor and the First-time Donor states. That transition period is removed because in the year 1979 a contribution of $50 or more entitled the donor to have his or her name listed in a directory of Major Donors, distributed to other Major Donors. In previous years, a $25 contribution was all that was necessary for one to receive special treatment as a Major Donor. The number entering the Major Donor category from the other states as defined in this mathematical model was greater in 1979 than in earlier years.

B. Analysis of Probability and Reward Vectors

The first step in analyzing the reward vectors was to find the average gift size made in going from one state to another. Table 10 below gives these values:

TABLE 10

AVERAGE GIFT SIZE MADE IN MAKING TRANSITIONS FROM 1975-1979

From/To	Major Donor	First-time Donor	Renewed Donor
Major Donor	$89.21	*	$23.00
Lapsed Major	$84.48	*	$17.50
First-time Donor	$58.46	*	$16.31
Renewed Donor	$53.96	*	$17.10
Lapsed Donor	$62.90	*	$14.99
New Member	$61.67	$13.35	*
Non-Donor	$71.71	$14.58	*

*Transition not possible.

Those staying in the Major Donor category gave more on the average than those just entering it. If a Major Donor did drop to the Renewed Donor state he or she gave more on the average than those staying in that state or just entering it for the first time. A New Member, being a recent graduate, who did give was likely to give less to get into the First-time Donor state than a Non-Donor, who by the nature of the state, had graduated at least one year prior to the New Member and presumably had more financial resources from which to draw upon.

If these revenue figures were the only components of the reward matrix, the association would be on Easy Street. However, there were many costs associated with going from one state to another. The cost accounting depended on both the starting state and the ending state under Epsilon's scheme. This contrasted with Tau Beta Pi's in-house fund-raising where the costs depended only on the ending state because all members received the same solicitation, regardless of their past giving pattern.

The cost components based on the starting state fell into two major categories: cost of initial mailing and cost of follow-up. The cost of the initial mailing depended on the type of solicitation package used. The costs shown here are based on the 1979 solicitations.

Major Donors and Lapsed Majors, since they showed the highest expected immediate rewards received "autotyped" letters soliciting contributions. One letter cost $1.10 to produce. Added to this were the cost of materials and fixed costs totalling $0.13 per letter and first class postage, which in 1979 was $0.15 per letter. The sum of these costs was $1.38.

If a Major Donor did not respond to the first letter with a contribution, he or she received a second "autotyped" letter. This second appeal, which also cost \$1.38 per letter, had to be sent to half of the original group. A third appeal, also consisting of an "autotyped" letter went to approximately 63 percent of those who received the second letter. So, the total expected cost of mailing to an individual in the Major Donor category was:

> Probability of making the first mailing times the cost of the first mailing plus the probability of making a second mailing times its cost plus the probability of making a third mailing times its cost ($1.0 \times 1.38 + .5 \times 1.38 + .5 \times .63 \times 1.38$).

This totalled \$2.51.

Appeals to the other types of donors were sent by third class bulk mail, at a rate of \$0.031 per letter. An address correction requested service on the envelopes was utilized. If the sendee had changed addresses, the envelope was not forwarded but was returned to the sender for \$0.25 fee. The follow-up appeals, which were sent to all who had failed to give on the first appeal, were then mailed to the new address. So, the starting state cost for the remaining states was found by multiplying the cost of each mailing by the probability of having to make it, as in the above case for Major Donors, and adding an expected cost of the address correction service equal to the cost of the service times the probability of it being used. Approximately 5 percent of each mailing sent by third class bulk was returned with an address correction.

For example, Non-Donors received an initial solicitation by third class bulk mail which cost a total of \$0.27 to produce. Since 5 percent of the envelopes were returned, the expected cost of the address correction service off the first mailing was \$0.0125 (.05 × \$0.25). Approximately 98 percent of the original group received a follow-up meaning that the expected cost for the second mailing was \$0.26 (\$0.27 × .98). Some envelopes were returned via the address correction mechanism again, adding \$0.0122 to the cost. This yielded a total cost of \$0.555 per Non-Donor.

The cost components of the ending state were functions of the ending state itself. There were no added costs if one entered one of the no-contribution states, but there were added costs if one entered either the Major Donor, First-time Donor, Renewed Donor, or Dead or Lost state.

Each gift was returned to the association in a business reply envelope. The cost of this service was \$0.18 per return. (There were a few members who sent their gifts in their personal envelopes, footing the postage themselves, thus, saving the association 18¢ in business reply service fees. Since this number was so small, however, it was not considered in the analysis.)

Each gift was acknowledged by a letter sent to the donor by first class mail whose printing, postage, and handling cost \$0.20 and by a listing in the association's quarterly magazine which cost \$0.50 per contributor to print (total cost of printing the magazine insert and allocated portion of the magazine postage costs of \$5,000 divided by

10,000 contributors). The cost to acknowledge Major Donors was increased by the publication and distribution of a Major Donor Booklet, which listed all members who contributed $50.00 or more. The book was sent to all Major Donors at a cost of $0.98 each. So, the total cost associated with ending in the Major Donor state was $1.86 (envelope cost of $0.18 plus letter acknowledgement of $0.20, magazine acknowledgement of $0.50 plus booklet cost of $0.98).

An additional cost of $0.25 per member was incurred for a member entering the Dead or Lost state to pay for the notification of death or address invalidity. This cost applied only to states whose solicitations were sent by third class mail. There was no charge for notification on pieces sent by first class mail.

To find a component of the reward vector the costs were subtracted from the revenue for making the transition from one state to another.

For example, the reward for staying in the Major Donor state from 1978 to 1979 equalled the average gift given in making that transition, $93.11, minus the cost for starting in that state, $2.51 minus the cost for ending in the Major Donor state, $1.86. The net reward totalled $88.74.

If the Major Donor in 1978 did not contribute in 1979 he or she entered the Lapsed Donor state. The "reward" for making this transition was -$2.51, the cost for starting in the Major Donor state, since no revenue was generated to offset this cost.

The validity of the model was tested using these cost statistics and the probability transition matrix for 1978 to 1979.

A test of the statistics derived from the computer analysis was conducted using a Markovian population model. The expected immediate reward for each state was found by taking the vector product of the probability vector for each state and the reward vector. For example, if the probability vector were [.1, .6, .3] and the reward vector were (3,5,-2) the expected immediate reward would be 2.7 (.1 × 3 + .6 × 5 + .3 × -2).

The expected immediate reward for a given state was multiplied by the number of individuals occupying that state in the beginning of the year. The sum of these products gave the expected net revenue for the year.

The probability transition matrix was:

	Major Donor	Lapsed Major	1st-time Donor	Renewed Donor	Lapsed Donor	Non-Donor	New Member	Dead or Lost
Major	.753	.183	.00	.043	.00	.00	.00	.021
L. Major	.297	.676	.00	.027	.00	.00	.00	.00
1st-time	.037	.00	.00	.444	.490	.00	.00	.029
Renewed	.064	.00	.00	.711	.214	.00	.00	.011
L. Donor	.009	.00	.00	.170	.798	.00	.00	.023
Non-D.	.002	.00	.02	.00	.00	.958	.00	.02
New	.001	.00	.051	.00	.00	.928	.00	.02
Dead	.00	.00	.00	.00	.00	.00	.00	.00

The values above were taken from the computer analysis of the sample of 2,100 contributors, except for the proportions leaving the Non-Donor and New Member states. The computer analysis, since it dealt only with contributors, provided the proportion of contributors who became Major Donors or First-time Donors after starting in either the Non-Donor or First-time states. These values were multiplied by the actual percentage of Non-Donors and New Members who contributed (.022 and .05 respectively) to derive the percentages in the above matrix. For example, the computer analysis showed 10 percent of the Non-Donors who contributed became Major Donors. Since 2.2 percent of all Non-Donors contributed, .2 percent of all Non-Donors became Major Donors (.10 × .022). The actual value of the percentage going from the Non-Donor state to the Non-Donor state, .958, and the percentage going from the New Member state to the Non-Donor state, .928, are used in the above matrix.

The reward matrix components were based on the average rewards found for going from one state to another in the computer analysis and costs for going from one state to another, which are enumerated in the following chapter. The chapter lists a number of strategies which may be applied to each state. The actual strategies used in 1979 for the respective states were:

Major Donor—Full Epsilon Program
Lapsed Major—Full Epsilon Program
First-time Donor—Full Epsilon Program
Renewed Donor—Full Epsilon Program
Lapsed Donor—Full Epsilon Program
Non-Donor—Selected Audience
New Member—Limited Epsilon Program.

For example, the reward matrix component for going from the Major Donor state to the Major Donor state, was found by taking the average gift made by an individual making that transition, \$93.11 and subtracting from it the costs associated with making that transition, \$4.37 (the sum of the costs, \$1.38 + .69 + .44 + .70 + .18 + .98, given on page 95 in Chapter IV). This yielded \$88.74. A cost of \$0.00 is shown where no transition between the two states was possible.

The expected revenues, costs, and their differences, which comprise the reward matrix components are shown in Table 11.

The expected immediate rewards for each state calculated by taking the vector product of the state's probability vector and its reward vector were:

Major Donor	—	\$67.01
Lapsed Major	—	15.12
1st-time Donor	—	7.71
Renewed Donor	—	14.10
Lapsed Donor	—	2.26
Non-Donor	—	-0.15
New Member	—	0.14

These expected immediate rewards underscored the value of getting as many members into the Major Donor state as possible. The high probability of staying in the state coupled with the net income generated yielded an expected income of \$67.01 from each individual starting in that state.

The state having the next highest value was Lapsed Major with \$15.12 followed closely by the Renewed Donor state with \$14.10. The

TABLE 11

REWARD MATRIX FOR 1979 SOLICITATION

	Major Donor	Lapsed Donor	1st-time Donor	Renewed Donor	Lapsed Donor	Non-Donor	New Member	Dead or Lost
Major Donor	93.11 -4.37 88.74	-2.51 -2.51	0.00 0.00	20.00 -3.39 16.61	0.00 0.00	0.00 0.00	0.00 0.00	-2.76 -2.76
Lapsed Major	63.64 -5.47 58.17	-3.61 -3.61	0.00 0.00	15.00 -4.49 10.51	0.00 0.00	0.00 0.00	0.00 0.00	-3.86 -3.86
1st-time Donor	50.00 -2.52 47.48	0.00 0.00	0.00 0.00	15.75 -1.54 14.21	-.66 -.66	0.00 0.00	0.00 0.00	- .91 - .91
Renewed Donor	52.66 -2.43 50.23	0.00 0.00	0.00 0.00	16.94 -1.45 15.49	-.57 -.57	0.00 0.00	0.00 0.00	- .82 - .82
Lapsed Donor	65.71 -2.65 63.06	0.00 0.00	0.00 0.00	15.46 -1.67 13.79	-.79 -.79	0.00 0.00	0.00 0.00	-1.04 -1.04
Non-Donor	60.00 -3.11 56.89	0.00 0.00	15.27 -1.43 13.84	0.00 0.00	0.00 0.00	-.55 -.55	0.00 0.00	- .80 - .80
New Members	50.00 -3.11 46.89	0.00 0.00	13.59 -1.43 12.16	0.00 0.00	0.00 0.00	-.55 -.55	0.00 0.00	- .80 - .80

trade-off between high rewards and high percentage entering a Donor state was shown here, as even though only 31 percent of Lapsed Majors entered one of the Donor states, as compared to 77 percent for the Renewed Donor, the higher rewards associated with the Lapsed Major state led to a higher expected immediate reward.

The Non-Donor state had a negative expected immediate reward, meaning that the cost per dollar raised was greater than one dollar. The justification for incurring this net loss will be shown in the next chapter.

The number of members in the respective states in the beginning of the year 1979 were:

Major Donor	—	983
Lapsed Major	—	173
1st-time Donor	—	2,260
Renewed Donor	—	7,187
Lapsed Donor	—	6,760
Non-Donors solicited	—	64,757
New Member	—	6,682

The expected net revenue found by multiplying the expected immediate rewards by the number beginning in the respective states was $193,747. The actual net revenue reported in the association's financial reports was $193,756.

The expected revenue equalled the product of the expected immediate revenue (gift amounts made in going to one of the donor states times the probability of making the transition to that donor state) times the number beginning in the respective states. This totalled \$258,149 as compared to actual revenue of \$257,842.

One may conclude that the information provided by the sample of 2,100 donors concerning the probability transition matrix and reward matrix yielded an accurate description of the fund-raising process for 1979.

C. An Experiment on Non-Donors

The thorn in the side of the fund-raising efforts as of 1980 had been the 70,000 members who had not contributed, despite numerous appeals to them. Most of those who contributed had given at least once in the past. Since these contributors must eventually be absorbed into the Dead or Lost state, Non-Donors must be enticed to contribute in order to sustain the donor base.

The Non-Donors had been broken into two categories for solicitation purposes. One group was Non-Donors who had maintained their subscriptions to the association's magazine. Only 3 percent of these members contributed in 1979, representing 1,076 gifts. The cost per dollar raised for this category was \$0.74.

An even worse showing came, as one might expect, from Non-Donors who did not maintain their magazine subscriptions. Only 379 gifts came from individuals in this category, or a 1.3 percent response rate. The cost per dollar raised was \$1.82. Epsilon recognized after the second year of its involvement with Tau Beta Pi that there were too many people in this category who were unwilling to contribute and that the cost of soliciting each one year after year was cutting deeply into the net receipts. Beginning in 1977, only 2/3 of the nondonor/nonsubscribers would be asked to contribute in the campaign year. The other 1/3 would not receive a solicitation.

Some of these members had been on the mailing list going as far back as 1972. The segmentation possibilities using the existing computer data base had been exhausted.

One characteristic which does not appear on the computer records which could be used was the class standing of the individuals when they became members. One must be in the top eighth of the junior engineering class or top fifth of the senior class to be considered for membership. One might expect those who became members as juniors (hereafter referred to as "juniors") to have a stronger loyalty to the organization since they were able to participate in their chapter's activities longer than those who became members in their senior year (hereafter referred to as "seniors").

If this distinction in the text of the fund-raising letters proved to stimulate more donations from the nondonor/nonsubscribers, it might be incorporated into letters to recent graduates being solicited for the first time (New Members). New Members were segregated from other past Non-Donors. They received a letter noting that this is the first time that they are being solicited. The value of this segmentation proved valuable since 5 percent of the New Members responded with gifts, a higher percentage than Non-Donors who had received one or more appeals in the past.

To see if segmenting the Non-Donors into juniors and seniors was worthwhile, an experiment comparing two proportions was derived. The hypothesis was that there was statistically significant difference between:

p_1—the proportion responding to a special letter whose text mentioned that the person became a member as a junior or senior

and

p_2—the proportion responding to a standard nondonor letter which made no distinction between juniors and seniors.

It was believed that the subjects of this experiment would respond as they had in previous campaigns, that is, only 1 to 2 percent would actually contribute. To determine the sample size needed to draw a statistically significant conclusion, p_1 was projected to be .025 and p_2 .0125, meaning that twice the number of individuals receiving a special letter would respond as compared to the standard letter.

Given that this sample comes from a binomial distribution, the normal approximation to the binomial was used to determine sample size. The number receiving the standard letter was to be the same as the number receiving the special letter, for simplicity. Duncan showed that this sample size, n, could be derived from:

$$(p_1 - p_2) \pm Z \sqrt{\sigma_{p_1} + \sigma_{p_2}} \geq 0 \tag{5}$$

where

$$\sigma^2_{p_i} = \frac{p_i(1 - p_i)}{n} \tag{6}$$

For a 95 percent confidence level, $Z = 1.96$. Solving for n yields $n = 903$. The final sample size was chosen to be 1,000, for convenience.

The identification of the members of the sample required data from Epsilon and the headquarters office. A list of 16,100 members who had not made a contribution in the past and who were not being solicited in the 1980 campaign was obtained from Epsilon. The Epsilon identification code includes a random letter which was used as the basis for drawing a random sample. Those members who had a "B," "G," "P," or "X" in their code constituted the sample.

The headquarters records were then consulted to see which members joined the organization as juniors and which joined as seniors. One thousand juniors and one thousand seniors were selected. (A few individuals do not become members as juniors or seniors, but as graduate students or after graduation as "eminent engineers." If any appeared on the Epsilon list, they were eliminated from the sample.) Each member filled out a personal data card upon joining. The cards for the 1,000 juniors and 1,000 seniors were pulled from the over 220,000 constituting the association's records. Knowing the date of initiation and the date of graduation given on the card, one could ascertain whether the member was a junior or senior. Half of those identified as juniors received the special letter, the others a standard letter. This selection was made simply by alternating the special and standard designation on the list of names. A similar method was used for the list of seniors to assure sample randomness.

Epsilon supplied gummed address labels for the 2,000 members. These labels were affixed to third class bulk rate envelopes, which may be sent by a nonprofit organization at the rate of 3.5¢ per envelope, rather than the first class rate of 15¢.

Each envelope contained an offset-printed letter. (The cost to produce a computer-generated letter for each member was deemed too expensive.) Along with the letter, a response slip, shown in Figure 3 and a business reply envelope, whose postage is paid by the addressee, were included in the envelope. Figures 4, 5, and 6 show copies of these letters.

As the contingency figure shows (Figure 7), not only could one draw conclusions about the value of a special letter versus a standard letter, one may also see if the juniors responded better than the seniors to either the standard letter, the special letter, and/or both.

The responses to the letters are summarized in Table 12. These results indicate that it would not be worthwhile to differentiate between juniors and seniors who have not contributed in the past. The extra cost which would be incurred in including the information in the data base and incurred in the handling of differentiated letters probably would not be recouped.

Seven respondents to the special letter (three juniors and four seniors) out of the mailing of 1,000 special letters corresponded to a p_1 equal to .007 while eight respondents to the standard letter (three juniors and five seniors) yielded a p_2 equal to .008.

THE TAU BETA PI ASSOCIATION
NATIONAL ENGINEERING HONOR SOCIETY
P.O. Box 8840, University Station
Knoxville, Tennessee 37916

FROM: ______________________

____

____

____

1980 ANNUAL ALUMNI CAMPAIGN.... I am enclosing the following contribution to help Tau Beta Pi encourage and recognize engineering excellence at our chapter schools.

( )$.....Other ( )$50 ( )$25 ( )$15 ( )$10

PLEASE RETURN THIS FORM WITH YOUR CHECK MADE PAYABLE TO TAU BETA PI

Figure 3. Response slip used in experiment.

THE TAU BETA PI ASSOCIATION
INCORPORATED
NATIONAL ENGINEERING HONOR SOCIETY
MEMBER OF ASSOCIATION OF COLLEGE HONOR SOCIETIES
FOUNDED 1885
P O BOX 8840, UNIVERSITY STATION
KNOXVILLE, TENNESSEE 37916
TELEPHONE 615/946-4578

SECRETARY-TREASURER
ROBERT H NAGEL

ASSISTANT SECRETARY-TREASURER
DAVID J SOUKUP

July 7, 1980

Dear Tau Bate:

One of the main reasons you were invited to join Tau Beta Pi during your junior year was that you had proven your ability to achieve academic excellence in engineering.

I'm writing today to seek your help to promote and recognize engineering students who possess similar records of achievement, at your alma mater and wherever Tau Beta Pi chapters are established.

In order to continue doing this, we depend on alumni support... voluntary contributions. So please, if you can, send $10, $15, or an amount larger or smaller. Your support is needed! You'll be recognized in THE BENT and, if you send $50 or more, you will qualify for inclusion in the 1980 Tau Beta Pi register of major alumni contributors.

Help us further reduce the initiation fee, increase the number of and dollar amounts of our Fellowship awards, and increase the scope of our District Program. Participate in the 1980 Alumni Appeal.

You benefited a great deal by becoming a Tau Bate in your junior year. You know how valuable and worthwhile the experience can be.

Please send a gift today. Your support will be deeply appreciated.

Sincerely,

Robert H. Nagel
New York Delta

RHN/ds

P.S. Please keep in mind that a gift to Tau Beta Pi is fully tax deductible.

Figure 4. "Special" letter sent to 500 juniors.

THE TAU BETA PI ASSOCIATION
INCORPORATED
NATIONAL ENGINEERING HONOR SOCIETY
MEMBER OF ASSOCIATION OF COLLEGE HONOR SOCIETIES

FOUNDED 1885

P O BOX 8840 UNIVERSITY STATION
KNOXVILLE TENNESSEE 37916
TELEPHONE 615/546 4578

SECRETARY-TREASURER
ROBERT H NAGEL

ASSISTANT SECRETARY-TREASURER
DAVID J SOUKUP

July 7, 1980

Dear Tau Bate:

One of the main reasons you were invited to join Tau Beta Pi during your senior year was that you had proven your ability to achieve academic excellence in engineering.

I'm writing today to seek your help to promote and recognize engineering students who possess similar records of achievement, at your alma mater and wherever Tau Beta Pi chapters are established.

In order to continue doing this, we depend on alumni support... voluntary contributions. So please, if you can, send $10, $15, or an amount larger or smaller. Your support is needed! You'll be recognized in THE BENT and, if you send $50 or more, you will qualify for inclusion in the 1980 Tau Beta Pi register of major alumni contributors.

Help us further reduce the initiation fee, increase the number of and dollar amounts of our Fellowship awards, and increase the scope of our District Program. Participate in the 1980 Alumni Appeal.

Remember how it felt to become a Tau Bate your senior year, how worthwhile and satisfying it was to receive the invitation? Help us reach out and offer that same distinction to qualified students for years to come.

Please send a gift today. Your support will be deeply appreciated.

Sincerely,

Robert H. Nagel
New York Delta

RHN/ds

P.S. Please keep in mind that a gift to Tau Beta Pi is fully tax deductible.

Figure 5. "Special" letter sent to 500 seniors.

THE TAU BETA PI ASSOCIATION
INCORPORATED
NATIONAL ENGINEERING HONOR SOCIETY
MEMBER OF ASSOCIATION OF COLLEGE HONOR SOCIETIES

FOUNDED 1885

P O BOX 8840 UNIVERSITY STATION
KNOXVILLE TENNESSEE 37916
TELEPHONE 615/546-4578

SECRETARY-TREASURER
ROBERT H NAGEL

ASSISTANT SECRETARY-TREASURER
DAVID J. SOUKUP

July 7, 1980

Dear Tau Bate:

Alumni from our 185 chapters helped lead the way to Tau Beta Pi's most successful Annual Fund Campaign last year.

But despite the generosity and strong response from over 11,000 Tau Bates, I can't say the program was a complete success... because we didn't hear from you.

I'm writing to you today because this month marks the beginning of the 1980 Alumni Fund.

Last year alumni made it possible to increase each of 18 Tau Beta Pi graduate Fellowships by one thousand dollars. Initiation fees have been reduced by one dollar again. And alumni contributions permitted us to get the District Program off to a good start last year. It benefits the collegiate chapters directly and offers a chance for interested alumni to take part in Tau Beta Pi activities at the local level. The program has a $50,000 budget this year, and it ought to grow.

Your support of Tau Beta Pi's work in these areas and others would be deeply appreciated. So please, if you can, send $10, $15, or an amount larger or smaller. Your support is needed! You'll be recognized in THE BENT and, if you send $50 or more, you will qualify for inclusion in the 1980 Tau Beta Pi register of major alumni contributors.

Please let me hear from you soon.

Sincerely,

Robert H. Nagel
New York Delta

RHN/ds

P.S. Please keep in mind that a gift to Tau Beta Pi is fully tax deductible.

Figure 6. "Standard" letter sent to 500 juniors and 500 seniors.

	junior	senior
Special letter	n_{1j}	n_{1s}
Standard letter	n_{2j}	n_{2s}

Figure 7. Fund-raising experiment matrix

Where n_{ik} is the number of donors who received letter version i and who were members of class k.

TABLE 12

LIST OF RESPONDENTS TO SOLICITATION LETTERS DIFFERENTIATED BY INDIVIDUALS' CLASS STANDING AT THE TIME OF INITIATION INTO TAU BETA PI

Year of Graduation	Amount Given	Year of Graduation	Amount Given
Special Junior		Special Senior	
1962	$10.00	1970	$10.00
1957	$10.00	1971	$10.00
1966	$25.00	1938	$15.00
		1975	$10.00
Standard Junior		Standard Senior	
1968	$10.00	1962	$ 10.00
1953	$ 5.00	1967	$ 50.00
1970	$10.00	1950	$100.00
		1972	$ 10.00
		1966	$ 50.00

Using the test statistic $Z = \frac{p_1 - p_2}{\sigma_{p_1 - p_2}}$ one obtained a value of Z equal to .259. Since .259 lay between the limits ± 1.96, one may accept the hypothesis that $p_1 = p_2$ and conclude that at the .05 level there was not a significant difference between the two types of letters.

Looking at the other set of contingency table statistics, junior versus senior, the proportion of juniors responding was .006 (three to the special letter and three to the standard letter) and a proportion of .009 seniors donated (four to the special letter and five to the standard letter). The Z value for the difference between these two proportions was .77. This also lay between the limits

$\pm$ 1.96, so one may accept the hypothesis that p_1, the proportion of juniors, equalled p_2, the proportion of seniors, at the .05 level of confidence.

With this relatively poor response, one may question if the responses were significantly more than zero. That is, with how much confidence can one predict, given these results, that one would contribute. The hypothesis was the proportion of those giving, p_0, equalled zero. The statistic is found using the formula.

$$Z = \frac{(\chi - .5) - np_0}{\sigma} \tag{7}$$

χ, the average number of respondents equalled 3.75, p_0 equalled zero, σ was found using the formula:

$$\sigma = \sqrt{npq} \tag{8}$$

With n = 500, σ equalled 1.93. Z, thus equalled 1.68. Since $Z_{.05}$ = 1.645 one can reject the hypothesis that $p_0 = 0$.

This experiment showed that it would not be worthwhile to consider segmentation by class year as one of the strategies for soliciting contributions from Non-Donors and New Members.

There may be other personal characteristics of the donors, such as occupation, which may be useful to investigate as a means of categorizing potential donors.

The remainder of the paper will focus on segmentation by past giving pattern of the members, the basis used by Epsilon.

Much of Epsilon's success may be traced to the ability to retain Major Donors once they were attracted to that category. In 1974 under the in-house program only 22 percent of the Major Donors stayed in that state as compared to an average of 73 percent during Epsilon's program.

The special treatment Lapsed Majors received under Epsilon's proved worthwhile as those who contributed after having lapsed for one year or more tended to go back to the Major Donor category by giving $50.00 or more rather than dropping into the Renewed Donor category by giving less than $50.00.

First-time Donor behavior was different from Renewed Donors'. Approximately 50 percent of the First-time Donors gave the following year, but 75 percent of the Renewed Donors gave again. This justified the unique treatment that Renewed Donors were given as compared to First-time Donors. The Renewed Donors were more likely to become Major Donors, as well.

The data showed that once a donor lapsed, he or she still deserved different handling from those who had never given. The Epsilon appeal brought over 20 percent of the individuals who had contributed at least once but had not given in the previous year back into the fold.

No comparison of the percentage going to a "Donor" state (First-time or Major) versus the Non-Donor state could be made for New Members and Non-Donors because of the nature of the data; all those who were in those states eventually became contributors in the sample whereas in actual practice, a high percentage became or stayed Non-Donors. The transition matrices did show that among those becoming "Donors" less than 5 percent made the "quantum leap" to the Major Donor state. Epsilon's aggregate statistics on Non-Donors and New Members gave some insight into their behavior. In 1979, for example, 5.2 percent of the New Members became "Donors" but only 2.2 percent became "Donors" from the Non-Donor state. This section described an experiment which looked at a variable, whose use, perhaps, would increase the percentage of Non-Donors going to a "Donor" state.

The nonhomogeneous nature of donor behavior showed in the percentage entering the Dead or Lost state. More members from earlier class years tended to be in the Major Donor and Lapsed Major states. Since these members were older they, naturally, had a higher probability of dying than the younger members. So, the percentage leaving the Major Donor and Lapsed Major states and entering the absorbing state, Dead or Lost, was higher than that entering the absorbing state from the First-time, Renewed, or Lapsed Donor states.

CHAPTER IV

ANALYSIS OF FUND-RAISING STRATEGIES

A. Enumeration of the Alternatives

The previous chapter concerned the history of Tau Beta Pi's fund-raising. It explored the results of various fund-raising options for each of the states of the system. Given these possibilities, this chapter examines the combination of the strategies which would yield the greatest benefits.

The analogy to engineering economy problems is that one must decide whether spending more in year one to generate greater revenue in the future will have a greater present value than spending a smaller amount earlier and seeing lower future revenues.

Tau Beta Pi had decided to abandon the lower cost in-house fund-raising in favor of Epsilon's. Was this the correct decision?

Yes, it appears that it was the right move because all costs were recouped in the first year of the program and the net income was far greater than that generated before.

Epsilon offered a number of other strategies to promote giving, some more expensive and others less expensive than the ones being used. Those options were explored, assuming that a Markov model with rewards was valid. The system was considered to be homogeneous. The validity of the model could be enhanced by accounting for variables such as graduation year, but the number of states involved became intractable.

Hence, the eight states of the model explored using Markov decision analysis were the same as those considered in the historical analysis of the previous chapter.

The strategies for each state fell into one of five basic categories. Some strategies may be applied to each state while other strategies would not be appropriate to a particular state. The general description of each strategy follows:

A. No Action—Individuals would stay in the same state they were in. No funds would be spent to try to get them out of that state, so the net income would be zero.

B. Undifferentiated—The members' previous giving pattern would not be taken into account. All members would receive the same form of appeal. This would be similar to the method used by Tau Beta Pi from 1966 to 1974.

C. Limited Epsilon Program—This method would use computer-generated letters to all members and follow-up mailings. No Major Donor booklet would be published. This would be similar to Epsilon's efforts from 1975 to 1977.

D. Single Letter Program—This would be similar to the Limited Epsilon program, with the exception that only one computer-generated letter would be sent to each potential contributor.

E. Full Epsilon Program—This method would incorporate all of the features of the Limited Epsilon Program and would add a Major Donor booklet to help encourage gifts of $50.00 or more.

Derivations of the reward vectors and tabulations of the probability transition vectors for the strategies of each state are given on the following pages. The values are based on the historical analysis in the previous chapter and projections made by Epsilon.

The costs which are common to all strategies are:

1. Each piece of first class mail costs $0.15 to send.
2. Each piece of third class bulk mail costs $0.03 to send.
3. Each piece of mail returned to Tau Beta Pi by business reply mail costs $0.18. All gifts are assumed to be sent in a business reply envelope.
4. Each piece of mail returned by the address correction requested mechanism costs $0.25 to be returned to Tau Beta Pi. Assume that 5 percent of any mailing sent out by third class bulk will be returned with an address correction.

The following abbreviations are used for the states of the system:

Major Donor — M.D.

Lapsed Major — L.M.

First-time Donor — 1st

Renewed Donor — R.D.

Lapsed Donor — L.D.

Non-Donor — Non.

New Member — N.M.

Dead or Lost — D.L.

If an element of a probability transition vector shows a probability of .00, no transition is possible between the two states.

Options for Major Donors

Undifferentiated. This would be similar to the campaigns conducted by Tau Beta Pi from 1966 until 1974. All members would be treated the same, regardless of their past giving pattern. The total cost of making the initial mailing would be \$0.13 per piece (postage—\$0.03 plus printing and handling—\$0.10). A follow-up mailing would be made to those whose envelopes are returned through the address correction requested mechanism. Approximately 3 percent would receive this follow-up. The expected cost of this follow-up per member initially mailed to (the basis for the cost figures for all categories) is \$0.01 (probability of receiving an address correction times the address correction cost plus the cost of the initial mailing which must be sent out again—.03 × [\$0.25 + \$0.13]). The gifts will not be acknowledged by either a letter or by a listing in the quarterly magazine. The donor's cancelled check will serve as his or her acknowledgement. The derivation of the reward vector's components along with the probability transition vector are shown in Table 13.

Limited Epsilon Program. This would be similar to the efforts conducted by Epsilon from 1975 to 1977. No Major Donor booklet would be published. Assume that half of the group would not respond to the first letter and would be sent a follow-up. Approximately 63 percent of the group that receives the second letter will not respond to it and will be sent a third letter. About 10 percent of those receiving the third letter will respond to it, making a total of 76 percent of the original

TABLE 13

REWARD AND PROBABILITY TRANSITION VECTORS FOR MAJOR DONORS—ON UNDIFFERENTIATED OPTION

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	\$50.00	\$0.00	\$0.00	\$20.00	\$0.00	\$0.00	\$0.00	\$0.00
cost of initial mailing	.13	.13		.13				.13
expected cost of follow-up	.01	.01		.01				.01
cost of bus. reply envel.	.18			.18				
cost of address correction								.25
total	\$49.68	-\$0.14	\$0.00	\$19.68	\$0.00	\$0.00	\$0.00	-\$0.39
				Probability Transition Vector				
From \ To								
Major Donor	.37	.59	.00	.02	.00	.00	.00	.02

group responding with some contribution. The cost of the initial mailing would be $1.37 (postage—$0.15, cost of autotyped letter—$1.10, fixed costs—$0.12). It would cost $0.70 to acknowledge each gift (a first class letter whose postage and handling total $0.20 plus a listing in the association's magazine which costs $0.50 per gift to print). A derivation of the reward vector's components and probability transition vector are shown in Table 14.

Full Epsilon Program. This would be similar to the programs conducted by Epsilon in 1978 and 1979. A Major Donor booklet would be published. The printing and postage costs for this booklet would total $0.98 (printing—$0.70, postage—$0.28). The costs for sending out three appeals and the gift acknowledgement would be $0.01 higher per cost item than for the Limited Epsilon Program to reflect the extra resources needed to produce it. Since a higher percentage would stay in the Major Donor category the expected average contribution is assumed to be lower than for the Limited Epsilon Program. Those additional members who would stay in the Major Donor category who would otherwise drop into the Renewed Donor state would be more likely to give just the minimum amount to stay Major Donors, which is $50.00. Thus, the overall average gift size would be reduced. The reward vector and probability transition vector are shown in Table 15.

Options for Lapsed Major Donors

Undifferentiated. The details are similar to those for the Undifferentiated Major Donor Program described earlier, as shown in Table 16.

TABLE 14

REWARD AND PROBABILITY TRANSITION VECTORS FOR MAJOR DONORS—ON LIMITED EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	\$80.00	\$0.00	\$0.00	\$25.00	\$0.00	\$0.00	\$0.00	\$0.00
cost of initial mailing	1.37	1.37		1.37				1.37
expected cost of second mailing	.68	.68		.68				.68
expected cost of third mailing	.43	.43		.43				.43
cost to acknowledge gift	.70			.70				
cost of bus. reply envel.	.18			.18				
total	\$76.64	-\$2.48	\$0.00	\$21.64	\$0.00	\$0.00	\$0.00	-\$2.48
				Probability Transition Vector				
From \ To								
Major Donor	.73	.22	.00	.03	.00	.00	.00	.02

TABLE 15

REWARD AND PROBABILITY TRANSITION VECTORS FOR MAJOR DONORS—
ON FULL EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$75.00	$0.00	$0.00	$25.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing	1.38	1.38		1.38				1.38
expected cost of second mailing	.69	.69		.69				.69
expected cost of third mailing	.44	.44		.44				.44
cost to acknowledge gift	.70			.70				
cost of bus. reply envel.	.18			.18				
cost of Major Donor booklet	.98							
total	$70.63	-$2.51	$0.00	$21.61	$0.00	$0.00	$0.00	-$2.51
				Probability Transition Vector				
From \ To								
Major Donor	.75	.22	.00	.01	.00	.00	.00	.02

TABLE 16

REWARD AND PROBABILITY TRANSITION VECTORS FOR LAPSED MAJOR DONORS—ON UNDIFFERENTIATED OPTION

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$50.00	$0.00	$0.00	$18.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing	.13	.13		.13				.13
expected cost of follow-up	.01	.01		.01				.01
cost of address correction								.25
cost of bus. reply envel.	.18			.18				
total	$49.68	-$0.14	$0.00	$17.68	$0.00	$0.00	$0.00	-$0.39
				Probability Transition Vector				
From \ To								
Lapsed Major	.05	.88	.00	.05	.00	.00	.00	.02

Limited Epsilon Program. The details would be similar to the Limited Epsilon Program for Renewed Donors which will be described. Each Lapsed Major Donor would receive up to three computer-generated letters sent via third class mail. Assume that 92 percent will not respond to the first letter, 95 percent will not respond to the second, and 96 percent will not respond to the third. This means a total of 17 percent of the original group will contribute (11 percent Major Donors and 6 percent Renewed Donors). The results for the reward and probability transition vectors for this program are shown in Table 17.

Full Epsilon Program. This would be similar to the Full Epsilon Program for Major Donors. Assume that 85 percent will not respond to the first letter, 90 percent will not respond to the second, and 98 percent will not respond to the third. The 17 percent who contribute are broken down as follows: 13 percent become Major Donors and 4 percent become Renewed Donors. These results are shown in Table 18.

Options for First-time Donors

Undifferentiated. The details are similar to the Undifferentiated Major Donor Program as shown in Table 19.

Limited Epsilon Program. The details would be similar to the Limited Epsilon Program for Major Donors with the exception that the envelopes would be mailed by third class bulk. The cost of the initial mailing would be $0.27. Thirty percent would respond to the first letter. Twenty-five percent of those receiving a second appeal would

TABLE 17

REWARD AND PROBABILITY TRANSITION VECTORS FOR LAPSED MAJOR DONORS—ON LIMITED EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	\$50.00	\$0.00	\$0.00	\$19.00	\$0.00	\$0.00	\$0.00	\$0.00
cost of initial mailing	.27	.27		.27				.27
expected cost of second mailing	.26	.26		.26				.26
expected cost of third mailing	.26	.26		.26				
cost of bus. reply envel.	.18			.18				
cost to acknowledge gift	.70			.70				
cost of address correction								.25
total	\$48.33	-\$0.79	\$0.00	\$17.33	\$0.00	\$0.00	\$0.00	-\$0.78
				Probability Transition Vector				
From \ To								
Lapsed Major	.11	.81	.00	.06	.00	.00	.00	.02

TABLE 18

REWARD AND PROBABILITY TRANSITION VECTORS FOR LAPSED MAJOR DONORS—ON FULL EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$50.00	$0.00	$0.00	$20.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing	1.38	1.38		1.38				1.38
expected cost of second mailing	1.17	1.17		1.17				1.17
expected cost of third mailing	1.06	1.06		1.06				1.06
cost to acknowledge gift	.70			.70				
cost of bus. reply envel.	.18			.18				
cost of Major Donor booklet	.98							
total	$44.53	-$3.61	$0.00	$15.51	$0.00	$0.00	$0.00	-$3.61
				Probability Transition Vector				
From \ To								
Lapsed Major	.13	.81	.00	.04	.00	.00	.00	.02

TABLE 19

REWARD AND PROBABILITY TRANSITION VECTORS FOR FIRST-TIME DONORS—ON UNDIFFERENTIATED OPTION

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$0.00	$0.00	$0.00	$13.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing				.13	.13			.13
expected cost of follow-up mailing				.01	.01			.01
cost of address correction								.25
cost of bus. reply envel.				.18				
total	$0.00	$0.00	$0.00	$12.68	-$0.14	$0.00	$0.00	-$0.39
			Probability Transition Vector					
From \ To								
First-time Donor	.00	.00	.00	.45	.54	.00	.00	.01

respond to it. Finally, 6 percent would send gifts in response to a third letter. The expected cost of the second mailing would be \$0.20 (probability of sending out second mailing times the cost of sending it out plus the probability of getting an address correction back from the first mailing times the cost of the address correction service [$.7 \times \$0.27 + .05 \times \$0.25$]). The expected cost of the third mailing would be \$0.16 (the probability of sending out a third letter times the cost of the third mailing plus the probability of getting an address correction off the second mailing times the address correction fee plus the probability of getting an address correction off the third mailing times the cost of the address correction fee [$.52 \times \$0.27 + .05 \times .70 \times \$0.25 + .05 \times .52 \times \$0.25$]). It was assumed that 5 percent of any third class mailing would be returned with an address correction. Hence, the probability of getting an address correction off the second mailing would be .035 (.05 times the probability of sending a second letter to a member of the original group, .70). The reward matrix components and probability transition vector are shown in Table 20.

Full Epsilon Program. This would be similar to the Limited Program for First-time Donors. A Major Donor booklet would be added to the basic Limited Program. The costs for sending out the three appeals would be \$0.01 more in each cost category. The reward and probability transition vectors for this program are shown in Table 21.

Single Letter Program. Under this program, only one computer-generated letter would be sent to each First-time Donor via

TABLE 20

REWARD AND PROBABILITY TRANSITION VECTORS FOR FIRST-TIME DONORS—ON LIMITED EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$50.00	$0.00	$0.00	$15.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing	.27			.27	.27			.27
expected cost of second mailing	.20			.20	.20			.20
expected cost of third mailing	.16			.16	.16			.16
cost of bus. reply envel.	.18			.18				
cost to acknowledge gift	.70			.70				
cost of address correction								.25
total	$48.49	$0.00	$0.00	$13.49	-$0.63	$0.00	$0.00	-$0.88
			Probability Transition Vector					
From \ To								
First-time Donor	.01	.00	.00	.49	.49	.00	.00	.01

TABLE 21

REWARD AND PROBABILITY TRANSITION VECTORS FOR FIRST-TIME DONORS—ON FULL EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$50.00	$0.00	$0.00	$15.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing	.28			.28	.28			.28
expected cost of second mailing	.21			.21	.21			.21
expected cost of third mailing	.17			.17	.17			.17
cost of bus. reply envel.	.18			.18				
cost to acknowledge gift	.70			.70				
cost of Major Donor booklet	.98							
cost of address correction								.25
total	$47.48	$0.00	$0.00	$13.46	-$0.66	$0.00	$0.00	-$0.91
				Probability Transition Vector				
From \ To								
First-time Donor	.015	.00	.00	.485	.49	.00	.00	.01

third class mail. A follow-up will be sent only if the original letter is returned by the address correction mechanism. The costs are similar to the Limited Epsilon Program for First-time Donors. The expected contribution amount is higher than for other First-time Donor options because it is assumed that those who contribute to the initial mailing will give a greater amount than those who wait for the second or third reminder to respond. The reward and probability transition vectors for this program are shown in Table 22.

Options for Renewed Donors

Undifferentiated. The details would be similar to the Undifferentiated Major Donor Program as shown in Table 23.

Limited Epsilon Program. The details are similar to the Limited Epsilon Program for Major Donors. The cost to make the initial mailing would be \$0.27 (computer letter—\$0.12, fixed costs—\$0.12, postage—\$0.03). Approximately 60 percent would receive a second letter, and 70 percent of those receiving a second letter would also receive a third letter. Assuming that 10 percent respond to the third letter, a total of 75 percent of the original group would have contributed. These results are shown in Table 24.

Full Epsilon Program. This program would be based on the Limited Epsilon Program for Renewed Donors. A Major Donor booklet would be added to entice more members to become Major Donors. The reward and probability transition vectors for this program are shown in Table 25.

TABLE 22

REWARD AND PROBABILITY TRANSITION VECTORS FOR FIRST-TIME DONORS—ON SINGLE LETTER PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$50.00	$0.00	$0.00	$16.50	$0.00	$0.00	$0.00	$0.00
cost of initial mailing	.27			.27	.27			.27
cost of follow-up	.03			.03	.03			.03
cost of bus. reply envel.	.18			.18				
cost to acknowledge gift	.70			.70				
cost of address correction								.25
total	$48.82	$0.00	$0.00	$15.32	-$0.30	$0.00	$0.00	-$0.55
				Probability Transition Vector				
From \ To								
First-time Donor	.01	.00	.00	.42	.56	.00	.00	.01

TABLE 23

REWARD AND PROBABILITY TRANSITION VECTORS FOR RENEWED DONORS—ON UNDIFFERENTIATED OPTION

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$50.00	$0.00	$0.00	$15.50	$0.00	$0.00	$0.00	$0.00
cost of initial mailing	.13			.13	.13			.13
expected cost of follow-up	.01			.01	.01			.01
cost of bus. reply envel.	.18			.18				
cost of address correction								.25
total	$49.68	$0.00	$0.00	$15.18	-$0.14	$0.00	$0.00	-$0.39
				Probability Transition Vector				
From \ To								
Renewed Donor	.01	.00	.00	.65	.33	.00	.00	.01

TABLE 24

REWARD AND PROBABILITY TRANSITION VECTORS FOR RENEWED DONORS—ON LIMITED EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$50.00	$0.00	$0.00	$16.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing	.27			.27	.27			.27
expected cost of second mailing	.15			.15	.15			.15
expected cost of third mailing	.12			.12	.12			.12
cost of bus. reply envel.	.18			.18				
cost to acknowledge gift	.70			.70				
cost of address correction								.25
total	$48.58	$0.00	$0.00	$14.58	-$0.54	$0.00	$0.00	-$0.79
				Probability Transition Vector				
From \ To								
Renewed Donor	.03	.00	.00	.72	.24	.00	.00	.01

TABLE 25

REWARD AND PROBABILITY TRANSITION VECTORS FOR RENEWED DONORS—
ON FULL EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$50.00	$0.00	$0.00	$15.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing	.28			.28	.28			.28
expected cost of second mailing	.16			.16	.16			.16
expected cost of third mailing	.13			.13	.13			.13
cost of bus. reply envel.	.18			.18				
cost to acknowledge gift	.70			.70				
cost of Major Donor booklet	.98							
cost of address correction								.25
total	$47.57	$0.00	$0.00	$13.55	-$0.57	$0.00	$0.00	-$0.82
				Probability Transition Vector				
From \ To								
Renewed Donor	.04	.00	.00	.71	.24	.00	.00	.01

Single Letter Program. This would be similar to the Single Letter Program for First-time Donors, as shown in Table 26.

Options for Lapsed Donors

Undifferentiated. The details are similar to the Undifferentiated Major Donor Program. Table 27 shows these results.

Single Letter Program. This would be similar to the Single Letter Program for Renewed Donors. These results are shown in Table 28.

Full Epsilon Program. This would be similar to the Full Epsilon Program for First-time Donors. Assume that 85 percent would not respond to the first letter, 95 percent would not respond to the second letter, and 98 percent would not respond to the third letter. The reward and probability transition vectors for this program are shown in Table 29.

Options for Non-Donors

No Solicitation. Individuals who did not contribute in the past would not be sent any solicitation letters. Assume that .5 percent go into the Dead or Lost state through a cost-free mechanism as shown in Table 30.

Undifferentiated. The details are similar to the Undifferentiated Program for Major Donors as shown in Table 31.

Full Epsilon Program. This would be similar to the Full Epsilon Program for Lapsed Donors. A follow-up mailing would be sent to the

TABLE 26

REWARD AND PROBABILITY TRANSITION VECTORS FOR RENEWED DONORS—ON SINGLE LETTER PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$50.00	$0.00	$0.00	$17.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing	.27			.27	.27			.27
cost of follow-up	.03			.03	.03			.03
cost of bus. reply envel.	.18			.18				
cost to acknowledge gift	.70			.70				
cost of address correction								.25
total	$48.82	$0.00	$0.00	$15.82	-$0.30	$0.00	$0.00	-$0.55
				Probability Transition Vector				
From \ To								
Renewed Donor	.02	.00	.00	.68	.29	.00	.00	.01

TABLE 27

REWARD AND PROBABILITY TRANSITION VECTORS FOR LAPSED DONORS—ON UNDIFFERENTIATED OPTION

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$0.00	$0.00	$0.00	$15.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing				.13	.13			.13
expected cost of follow-up				.01	.01			.01
cost of bus. reply envel.				.18				
cost of address correction								.25
total	$0.00	$0.00	$0.00	$14.68	-$0.14	$0.00	$0.00	-$0.39
			Probability Transition Vector					
From \ To								
Lapsed Donor	.00	.00	.00	.10	.88	.00	.00	.02

TABLE 28

REWARD AND PROBABILITY TRANSITION VECTORS FOR LAPSED DONORS— ON SINGLE LETTER PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$0.00	$0.00	$0.00	$16.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing				.27	.27			.27
cost of follow-up				.03	.03			.03
cost of bus. reply envel.				.18				
cost to acknowledge gift				.70				
cost of address correction								.25
total	$0.00	$0.00	$0.00	$14.82	-$0.30	$0.00	$0.00	-$0.55
				Probability Transition Vector				
From\To								
Lapsed Donor	.00	.00	.00	.18	.80	.00	.00	.02

TABLE 29

REWARD AND PROBABILITY TRANSITION VECTORS FOR LAPSED DONORS—ON FULL EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$50.00	$0.00	$0.00	$15.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing	.27			.27	.27			.27
expected cost of second mailing	.26			.26	.26			.26
expected cost of third mailing	.26			.26	.26			.26
cost of bus. reply envel.	.18			.18				
cost to acknowledge gift	.70			.70				
cost of Major Donor booklet	.98							
cost of address correction								.25
total	$47.35	$0.00	$0.00	$13.33	-$0.79	$0.00	$0.00	-$1.04
				Probability Transition Vector				
From\To								
Lapsed Donor	.01	.00	.00	.17	.80	.00	.00	.02

TABLE 30

REWARD AND PROBABILITY TRANSITION VECTORS FOR NON-DONORS—ON NO SOLICITATION

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
total	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
				Probability Transition Vector				
From \ To								
Non-Donor	.00	.00	.00	.00	.00	.995	.00	.005

TABLE 31

REWARD AND PROBABILITY TRANSITION VECTORS FOR NON-DONORS—ON UNDIFFERENTIATED OPTION

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$0.00	$0.00	$12.00	$0.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing			.13			.13		.13
expected cost of follow-up			.01			.01		.01
cost of bus. reply envel.			.18					
cost of address correction								.25
total	$0.00	$0.00	$11.68	$0.00	$0.00	-$0.14	$0.00	-$0.39
				Probability Transition Vector				
From \ To								
Non-Donor	.00	.00	.01	.00	.00	.97	.00	.02

98 percent who would be expected not to respond to the first letter. The address correction fee for both the first and second mailings is included in the expected cost of the follow-up. The results of this program can be seen in Table 32.

Selected Audience. This method would be similar to the method employed by Epsilon beginning in 1977. This strategy would call for soliciting only one-third of the Non-Donors each year; the other two-thirds would receive no letter during the year. A different third would be solicited each year, meaning that a Non-Donor would be solicited once every three years, as long as he or she had a good address.

The probability transition and reward vectors are based on the entire population of a state and not a fraction of it. To get the vector into the proper form the following mathematical procedure would be used:

Let 1/Q be the fraction of Non-Donors being solicited.

Let X be the proportion of those solicited who contribute.

Let W be the reward associated with contributing (going to the First-time Donor state).

Let Z be the reward associated with not contributing (staying in the Non-Donor state).

The proportion of the total group contributing would be X/Q. The proportion of the group not contributing would equal the proportion not solicited plus the proportion solicited which did not contribute,

$$(1 - 1/Q) + (1/Q)(1 - X) \ . \qquad (5)$$

TABLE 32

REWARD AND PROBABILITY TRANSITION VECTORS FOR NON-DONORS—
ON FULL EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$0.00	$0.00	$15.00	$0.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing			.27			.27		.27
expected cost of follow-up			.28			.28		.28
cost of bus. reply envel.			.18					
cost to acknowledge gift			.70					
cost of address correction								.25
total	$0.00	$0.00	$13.57	$0.00	$0.00	-$0.55	$0.00	-$0.80
				Probability Transition Vector				
From \ To								
Non-Donor	.00	.00	.02	.00	.00	.96	.00	.02

The reward for going to the First-time Donor state for the group would be W/Q (1/Q of the group is asked to give, those who contribute give an average of W dollars).

The expected immediate reward for the proportion of the group solicited would be (1 - X)Z/Q. This term must be divided by the proportion of those not contributing (shown in (5) above) to find the reward for the entire group. The quotient equals

$$Z(1 - X) / (Q - X) . \tag{6}$$

For this example, Q would be equal to 3 (1/3 of the group is being solicited). Two percent of those solicited would give, so X would equal .02. Two percent of the entire group would enter the Dead or Lost state.

The reward for those solicited who become First-time Donors would be $13.57. The reward for staying in the Non-Donor state would be -$0.55.

Given the factors above, the probability of a Non-Donor going to the First-time Donor state would be .00667 (.02/3). However, 2 percent of the group was assumed to become Dead or Lost, so the actual proportion of those becoming First-time Donors would be .0065 (.0067 × .98). The reward for making this transition would be $4.52 ($13.57/3).

From (5), the probability of staying in the Non-Donor state would equal .9933 [(1 - 1/3) + (1/3))1 - .02)]. Again since 2 percent of the group is expected to become Dead or Lost, the actual proportion staying in the Non-Donor state would be .9735 (.9933 × .98).

From (6), the reward for staying in the Non-Donor state would be -\$0.18 (-\$0.55 (1 - .02) / (3 - .02)). These results are shown in Table 33.

TABLE 33

REWARD AND PROBABILITY TRANSITION VECTORS FOR NON-DONORS—ON SELECTED AUDIENCE

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
total	\$0.00	\$0.00	\$4.52	\$0.00	\$0.00	-\$0.18	\$0.00	-\$0.80
				Probability Transition Vector				
From \ To								
Non-Donor	.00	.00	.0065	.00	.00	.9735	.00	.02

Options for New Members

Undifferentiated. The details would be similar to the Undifferentiated Major Donor Program, as shown in Table 34.

Limited Epsilon Program. This would be similar to the Full Epsilon Program for Non-Donors, as shown in Table 35.

Full Epsilon Program. Under this option, soon after members graduate they would receive letters congratulating them on their graduation. They would be asked to return a questionnaire giving their new permanent address. Approximately 80 percent would return the form.

TABLE 34

REWARD AND PROBABILITY TRANSITION VECTORS FOR NEW MEMBERS—ON UNDIFFERENTIATED OPTION

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$0.00	$0.00	$10.00	$0.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing			.13			.13		.13
expected cost of follow-up			.01			.01		.01
cost of bus. reply envel.			.18					
cost of address correction								.25
total	$0.00	$0.00	$ 9.68	$0.00	$0.00	-$0.14	$0.00	-$0.39
			Probability Transition Vector					
From\To								
New Member	.00	.00	.03	.00	.00	.94	.00	.03

TABLE 35

REWARD AND PROBABILITY TRANSITION VECTORS FOR NEW MEMBERS—ON LIMITED EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$0.00	$0.00	$13.00	$0.00	$0.00	$0.00	$0.00	$0.00
cost of initial mailing			.27			.27		.27
expected cost of follow-up			.28			.28		.28
cost of bus. reply envel.			.18					
cost to acknowledge gift			.70					
cost of address correction								.25
total	$0.00	$0.00	$11.57	$0.00	$0.00	-$0.55	$0.00	-$0.80
				Probability Transition Vector				
From \ To								
New Member	.00	.00	.03	.00	.00	.94	.00	.03

The total cost for a letter and questionnaire would be \$0.43 (postage and handling for the computer-generated letter—\$0.27 plus the probability of returning the questionnaire times the cost of the business reply envelope the form would be mailed in—\$0.15 (.80 × \$0.18) plus the probability of getting an address correction off this questionnaire mailing times the address correction fee \$0.01 (.05 × \$0.25)).

The purpose of this address confirmation mailing would be to reduce the proportion of New Members entering the Dead or Lost category. This may prove beneficial in the long run because many young members become Lost shortly after their graduation. The results of this program are shown in Table 36.

B. Selection of Optimum Strategies

The parameters of the strategies given in the previous section were put into the computer program shown in the appendix which is based on Howard's Value Iteration—Policy Improvement algorithm. The optimal policy was the one which maximized the total expected return for each state.

The discount rate was chosen to be .95. It was assumed that the contribution amounts would keep up with the rate of inflation. The discount rate thus only reflected the time value of money and not the inflation rate. There was no after-tax analysis conducted, which one would have to do for a profit-making concern, because Tau Beta Pi pays no taxes.

TABLE 36

REWARD AND PROBABILITY TRANSITION VECTORS FOR NEW MEMBERS—ON FULL EPSILON PROGRAM

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
				Reward Vector				
expected contribution amount	$0.00	$0.00	$14.00	$0.00	$0.00	$0.00	$0.00	$0.00
const. of congrat. letter			.43			.43		.43
cost of initial solicitation			.27			.27		.27
expected cost of follow-up			.28			.28		.28
cost to acknowledge gift			.70					
cost of address correction								.25
total	$0.00	$0.00	$12.32	$0.00	$0.00	-$0.98	$0.00	-$1.23
				Probability Transition Vector				
From \ To								
New Member	.00	.00	.04	.00	.00	.95	.00	.01

The options which yielded the highest present values for each state are shown in Table 37.

TABLE 37

RESULTS OF COMPUTER PROGRAM ANALYZING FUND-RAISING STRATEGIES

State	Option	Present Value
Major Donor	Full Epsilon Program	361.41
Lapsed Major	Full Epsilon Program	237.53
First-time Donor	Full Epsilon Program	159.31
Renewed Donor	Full Epsilon Program	176.41
Lapsed Donor	Full Epsilon Program	141.71
Non-Donor	Full Fpsilon Program	31.30
New Member	Full Epsilon Program	33.85

The present values given in Table 37 are the asymptotes to the curves shown in Figure 8. The points on the curve were obtained by running a computer program which found the total expected reward of being in a state given that a number of time increments are left in the process.

For example, if a horizon of 20 years were chosen, the present worth of a single Major Donor based on his or her expected giving pattern during those 20 years would be $301.90 (the point circled in Figure 8). The present worth of a Non-Donor for that same time span would be $10.90 (the point with the square around it in Figure 8).

The total present worth of the system may be found using a Markovian population model. For example, what would be the present worth of the system for a 20-year time span? At the beginning of the

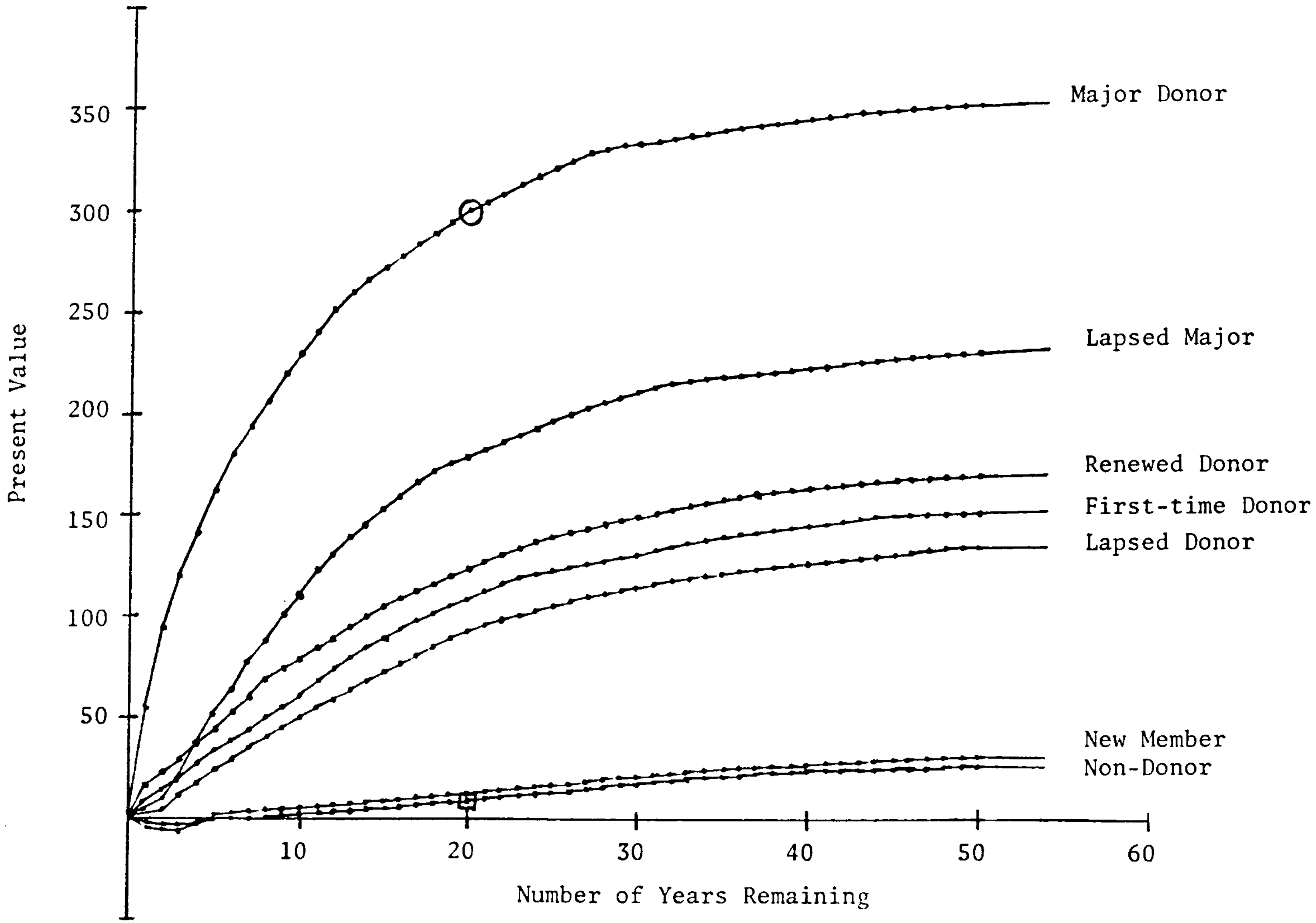

Figure 8. Present value versus time in the system for each state.

time span, there would be a number of members occupying each of the states. New Members would enter the system in each of the 20 years. Figure 8 shows that the present worth of a New Member declines as the number of years remaining decreases. This present worth becomes negative with 4 years remaining. Since these last four years would not add to the present value, one may assume that New Members would not be solicited during those final years.

One would first multiply the number of members occupying each state by the present worth of an individual in that state. Then one would add the present worth of the New Members, which would equal the number of New Members entering each year times the present value of a New Member for that year.

Assume that the population is broken down as follows:

1,000 Major Donors

200 Lapsed Majors

2,000 First-time Donors

7,000 Renewed Donors

7,000 Lapsed Donors

75,000 Non-Donors

9,000 New Members entering each year.

For example, the total present worth of the 1,000 Major Donors would be \$301,900 (1,000 × \$301.90), the total present worth of the 9,000 New Members entering with 20 years remaining would be \$113,400, and the total present value of the 9,000 New Members entering with 4 years remaining would be \$135.

The total present worth for the 20-year time horizon would be \$3,762,400. If the horizon were expanded to 30 years, the total present value would be \$6,291,320.

The computer program was run assuming that the Full Epsilon Program options for each state were not available. The total present value for a 20-year horizon using the next-best strategy for each state would be \$2,496,310.

One may calculate the total present value for a new fund-raising plan. That is, assume that there would be no Major Donors, Lapsed Majors, etc. initially. There would only be 100,000 New Members at the beginning of the 20-year horizon with 9,000 New Members entering the system each year. The total present worth would be \$2,021,040, if the Full Epsilon Program were used for each state.

Given the transition matrix corresponding to the optimum strategies, a number of statistics were derived using properties of absorbing Markov chains.

The transition matrix was arranged so that the absorbing state was in the upper left hand cell. The vector of values below this cell showed the probability of entering the absorbing state from the transient states. The remaining 7 × 7 submatrix showed the transitions among the transient states. The matrix is shown as follows:

	D.L.	M.D.	L.M.	R.D.	L.D.	1st	Non.	N.M.
D.L.	1.0	.00	.00	.00	.00	.00	.00	.00
M.D.	.02	.75	.22	.01	.00	.00	.00	.00
L.M.	.02	.13	.81	.04	.00	.00	.00	.00
R.D.	.01	.04	.00	.71	.24	.00	.00	.00
L.D.	.02	.01	.00	.17	.80	.00	.00	.00
1st	.01	.015	.00	.485	.49	.00	.00	.00
Non.	.02	.00	.00	.00	.00	.02	.96	.00
N.M.	.01	.00	.00	.00	.00	.04	.95	.00

Based on the above matrix, a matrix showing the expected number of years one may expect to stay in state j, given that one started in state i, was derived. It is shown below:

state j state i	M.D.	L.M.	R.D.	L.D.	1st	Non.	N.M.
M.D.	15.3	17.7	10.0	12.0	0.0	0.0	0.0
L.M.	12.4	19.6	10.6	12.7	0.0	0.0	0.0
R.D.	9.2	10.7	17.7	21.2	0.0	0.0	0.0
L.D.	8.6	10.0	15.5	23.6	0.0	0.0	0.0
1st	8.9	10.3	16.3	22.0	1.0	0.0	0.0
Non.	4.5	5.2	8.2	11.0	.5	25.0	0.0
N.M.	4.6	5.3	8.4	11.3	.5	23.7	0.0

By summing across any row i, one may find the expected length of time an individual who starts in state i would stay in the system before being absorbed into the Dead or Lost state.

For example, an individual starting in the New Member state would be expected to be a Major Donor for 4.6 years and a Donor for

8.9 years (a Renewed Donor for 8.4 years plus a First-time Donor for .5 years). This individual would be expected to remain in the system for 53.8 years before being absorbed into the Dead or Lost state.

The vector below shows the number of years an individual would remain in a nonabsorbing state once it was entered:

M.D.	L.M.	R.D.	L.D.	1st	Non.	N.M.
4.0	5.3	3.4	5.0	1.0	25.0	1.0

Since one never returns to the New Member or First-time Donor states, the number of years spent in those states would be one. Once the Non-Donor state were entered, however, one would be expected to stay in it for 25 years. A Major Donor or Renewed Donor would not be expected to remain in that state more than four consecutive years. The state may, of course, be re-entered later.

The matrix below shows the probability that one would ever go from state i to state j at some time while he or she were in the system:

state j state i	M.D.	L.M.	R.D.	L.D.	1st	Non.	N.M.
M.D.	.93	.90	.57	.51	.00	.00	.00
L.M.	.81	.95	.60	.54	.00	.00	.00
R.D.	.60	.54	.94	.90	.00	.00	.00
L.D.	.56	.51	.88	.96	.00	.00	.00
1st	.58	.53	.92	.93	.00	.00	.00
Non.	.29	.26	.46	.46	.50	.96	.00
N.M.	.30	.27	.48	.48	.51	.95	.00

For example, a New Member would have a 51 percent chance of becoming a donor at some time (.51 being the entry in the matrix for the transition from New Member to First-time Donor).

C. Sensitivity Analysis

The policy-improvement equation provided the basis for the sensitivity analysis.

The optimum alternative for each state was chosen by substituting the p_{ij} and r_{ij} values for each alternative into the expression:

$$\sum_{j=1}^{n} p_{ij}r_{ij} + d\sum_{k=1}^{n} p_{ik}v_k \; . \tag{9}$$

Call the values of p and r corresponding to the optimum alternative p_{ij}^b and r_{ij}^b. So, when substituted into the above expression p_{ij}^b and r_{ij}^b yielded the highest value.

To test the sensitivity of the r_{ij}^b's, one may find the minimum value the optimum reward r may take on and keep its strategy the optimum for that state. Let r* be this lower bound; $[v_k]$, the set of test quantities; v^b, the highest valued test quantity, which identifies the optimum alternative; and v*, the next highest valued test quantity. That is,

$$v^b = \sum_{j=1}^{n} p_{ij}^b r_{ij}^b + d\sum_{k=1}^{n} p_{ik}^b v_k \; . \tag{10}$$

To examine the sensitivity of the reward for going from state i to state j, the variable r* was substituted into the equation for the value r_{ij}^b and v* was substituted for v^b. The resulting equation was:

$$v^* = p_{ij}^b r^* + \sum_{\substack{m=1 \\ m \neq j}}^{n} p_{im} r_{im} + d \sum_{k=1}^{n} p_{ik}^b v_k \ . \tag{11}$$

A value for r* was found. If the reward were to fall below r*, another strategy would become a candidate to enter the solution.

This method held as long as the test quantities, v_k, were obtained using the parameters from nonoptimum vectors. That is, the v_k's were calculated using p_{ij} and r_{ij} values of alternatives which were not themselves being subjected to sensitivity analysis. Otherwise, one would have to go back many iterations in the value-determination policy-improvement scheme and begin the sensitivity analysis from the point where the optimum p_{ij} and r_{ij} appeared and work forward to the final iteration. This sensitivity analysis deals only with the last iteration.

For example, the highest valued test quantity for the Renewed Donor state was 157.91, which corresponded to the Full Epsilon Program option for that state. The next highest valued test quantity was 156.53, which corresponded to the Limited Epsilon Program option. The quantity examined was the reward associated with the transition from the Renewed Donor state back to the Renewed Donor state. This value, as shown in Table 25, page 108, of the previous section was set at \$13.55. The maximum it may change, Δ, before the Full Epsilon Program would be forced out of the solution and the Limited Epsilon Program option enters was found from the following formula:

$$156.53 = (.04 \times 47.57) + (.24 \times -.57) + (.01 \times -.82) + (.71 \times (13.55 - \Delta)) + .95 \times ((.04 \times 348.13) + (.71 \times 156.53) + (.24 \times 121.6) + (.01 \times 0))\ .$$

The value for Δ equalled 1.95. So, if the reward for staying in the Renewed Donor state fell below \$11.60 (\$13.55 - \$1.95), another strategy would enter the solution. This value of Δ may arise in actual practice from a decrease in income, an increase in cost, or both.

There were some instances where the rewards for entering one of the donor states could fall below zero and the strategy remains in the solution. This would occur if it were so important to get members into one of the donor states, where the probabilities of giving in the future were much higher than in the nondonor states, that the cost of getting them into that state would exceed the revenue generated.

Table 38 shows the reward for the strategy chosen as the optimum and the lower bound it may take on which would keep the strategy in the solution.

The sensitivity of the reward for going from one state to another was a function of the probability of making the transition. For example, the probability of going from the First-time Donor state to the Renewed Donor state was .485 compared to .015 for going from the First-time Donor state to the Major Donor state. A 16 percent drop in the reward for making the transition from First-time Donor to Renewed Donor would cause a change in strategies, whereas it would take a 145 percent drop in the reward for making the transition from First-time Donor to Major Donor before another strategy would enter the solution.

TABLE 38

SENSITIVITY ANALYSIS OF THE REWARDS

	M.D.	L.M.	1st	R.D.	L.D.	Non.	N.M.	D.L.
M.D.	70.63 70.34	-2.51 -3.55		21.61 -1.39				-2.76 -14.26
L.M.	44.53 34.14	-3.61 -5.27		15.51 -18.24				-3.06 -71.36
1st	47.48 -21.48			13.46 11.31	-0.66 -2.78			-0.91 -104.91
R.D.	47.57 12.82	13.55 11.59			-0.57 -6.36			-0.82 -139.82
L.D.	47.37 -101.63			13.33 4.56	-0.79 -2.65			-1.04 -75.54
Non.			13.57 -41.43			-0.55 -1.69		-0.80 -55.80
N.M.			12.32 -6.18			-0.98 -1.76		-1.23 -75.23

The sensitivity of the probability transition vectors was measured using the same test quantity as for the rewards. Since the sum of the transition probabilities for a vector must, by definition, equal one, the probabilities are dependent on one another. The analysis concerned the trade-off of going from one state to another. (Of course, three, four, or more states may have their probabilities changed simultaneously, with the resultant probabilities still summing to one. This analysis will only make pairwise comparisons of probabilities.) That is, let p_{ij}^{b}, the probability corresponding to the optimum alternative, decrease by Δ to p^*_{ij}. Then another probability in the vector must increase by Δ to p^*_{ih}. These quantities were substituted into the expression:

$$v^* = p^*_{ij} r^b_{ij} + p^*_{ih}\, r^b_{ih} + \sum_{\substack{m=1\\ m\neq j\\ m\neq h}}^{n} p^b_{im} r^b_{im} + d(p^*_{ij} v_j + p^*_{ih} v_h + \sum_{\substack{m=1\\ m\neq j\\ m\neq h}}^{n} p^b_{im}\, v_m)$$

Through appropriate substitution, the quantity Δ was found for various combinations for each of the probabilities for each of the states. If the value of the change would fall above the value Δ, another alternative would become a candidate for the solution.

For example, the largest valued test quantity for the Lapsed Donor state was 123.1, which corresponded to the Full Epsilon Program strategy. The next highest valued quantity was 121.6, which corresponded to the Single Letter Program. The trade-off between the probability of going from the Lapsed Donor state to the Renewed Donor state (originally .17) was made with the probability of staying in the Lapsed Donor state (originally .80). The trade-off factor Δ was found from the equation:

$$121.6 = 13.33(.17 - \Delta) - .79(.8 + \Delta) + 47.35\ (.01) - 1.04\ (.02) + .95(156.5(.17 - \Delta)) + 121.6\ (.8 + \Delta) + 348.1(.01))\ .$$

The value of Δ was .03, meaning that if the probability of going from the Lapsed Donor state to the Renewed Donor state fell below .14 (.17 - .03), another strategy should be selected.

Table 39 lists the tradeoffs between the transition probabilities for going from one state to another for each of the states.

The nature of the solution method precluded using any formula to determine the sensitivity of the discount rate. The computer

TABLE 39

SENSITIVITY ANALYSIS OF THE TRANSITION PROBABILITIES

Major Donor to:	Major Donor	Lapsed Major	Renewed Donor
current value	.75	.22	
bounds	.748	.222	
current value	.75		.01
bounds	.749		.011
current value		.22	.01
bounds		.226	.004
Lapsed Major to:	**Major Donor**	**Lapsed Major**	**Renewed Donor**
current value	.13	.81	
bounds	.122	.818	
current value		.81	.04
bounds		.84	.01
current value	.13		.04
bounds	.124		.046
First-time Donor to:	**Major Donor**	**Renewed Donor**	**Lapsed Donor**
current value		.485	.49
bounds		.475	.50
current value	.015		.49
bounds	.018		.487
current value	.015	.485	
bounds	.011	.489	
Renewed Donor to:	**Major Donor**	**Renewed Donor**	**Lapsed Donor**
current value		.71	.24
bounds		.68	.27
current value	.04		.24
bounds	.035		.245
current value	.04	.71	
bounds	.034	.716	

TABLE 39 (continued)

Lapsed Donor to:	Major Donor	Renewed Donor	Lapsed Donor
current value		.17	.80
bounds		.14	.83
current value	.01	.17	
bounds	.003	.177	
current value	.01		.80
bounds	.005		.805
Non-Donor to:		First-time Donor	Non-Donor
current value		.02	.96
bounds		.013	.967
New Member to:		First-time Donor	Non-Donor
current value		.04	.95
bounds		.035	.955

program was simply rerun, using a different discount rate each time, to establish the states which would enter the solution as the rate changed. Figure 9 shows the options which should be used for each state under various discount rates.

Discount Rate	.975	.95	.85	.80	.75	.70
State						
Major Donor	Full Epsilon →	Limited Epsilon →	→	→	→	→
Lapsed Major	Full Epsilon →	→	Limited Epsilon →	→	→	→
First-time Donor	Full Epsilon →	→	→	→	→	→
Renewed Donor	Full Epsilon →	→	→	→	→	→
Lapsed Donor	Full Epsilon →	→	→	→	→	→
Non-Donor	Full Epsilon →	→	→	→	Undifferentiated →	→
New Member	Full Epsilon →	→	Undifferentiated →	→	→	→

Figure 9. Sensitivity analysis of the discount rate.

CHAPTER V

CONCLUSIONS

A. The Model and Its Results

A number of alternatives for raising funds for nonprofit organizations was presented. Some techniques, such as the acquisition of grants, were not amenable to forecasting. Other techniques could be quantified, however, so that engineering economic analysis could be performed on them.

Direct mail fund-raising was chosen as the fund-raising method explored because, with the proper selection of states of the system, it could be modelled as a Markov chain. The probability and reward matrices gave an accurate description of the total revenue and net income generated during one fund-raising year.

An experiment was conducted to evaluate the fund-raising alternative of segmenting Non-Donors by their class standing when they became members of Tau Beta Pi. It compared the differences in responses (measured in terms of the percentage of the group contributing) between those who became members as juniors and those who became members as seniors and between those who received a letter noting their class standing when they became members and those who received a letter which made no mention of their class standing. The response was too small to be conclusive.

The poor results might be attributed to the uniformity of the letters. The letters printed for the experiment were not "personalized," meaning that items such as the potential donor's name were not included in each letter's text. Personalized computer-generated letters, which are more likely to attract the reader's attention than ones which are offset-print, have proven to generate better results than identical form letters.

The alternatives which did warrant further investigation were based on segmentation according to past giving patterns. Each category of member has a pattern of probability of donating and of donation amounts and these values are shown in the probability transition vectors and reward vectors. The vectors of the strategies were evaluated using Howard's Value Determination—Policy Improvement Algorithm. The optimum strategies for each state proved to be the most costly ones. The present worth of the stream of cash flows which would result from a policy using the highest cost strategies was greater than the present worth of any other policy.

The problem formulation provided statistics such as the probability that a New Member would eventually become a donor.

This study presents results which support the idea of direct-mail fund-raising. These statistics justify the seemingly high cost of fund-raising administration, expressed as a percentage of total donations. The initially high administration costs should be overcome by revenues over subsequent years.

Sensitivity analysis on the parameters underscored the need to monitor the actual results of the campaigns as compared to the forecasts. If the probability of going to a donor state or the rewards of making the transition to a donor state were to fall below certain bounds, another strategy should be considered.

The parameters associated with getting an individual who had not contributed in the previous year to give in the current year had a low sensitivity. That is, it would be so important to get noncontributors into a donor state, where the probability of giving is much higher than in a noncontributing state, that it would be acceptable for the expected cost of getting them into that state to be greater than the expected revenue. Over the long-term this deficit would be offset by expected future gifts.

If the discount rate would fall below .95, the present worth of future revenues would decrease. Strategies would enter the solution which show higher net income in the immediate years.

B. Recommendations for Future Research

A problem with the proposed model is the interdependence of the strategies. That is, it is possible for the solution to call for a strategy for one state to include the publication of a Major Donor Booklet, while the optimum strategy for another state may say that the cost of the booklet would not be justified. A zero-one programming formulation could remove the possibility of such inconsistencies.

Further, a goal programming formulation would allow nonfinancial constraints to be met. In addition to maximizing net income, other objectives such as keeping the administrative costs below a given percent of revenues, limiting the number of letters to any one individual over a span of years, or maximizing gross income could be incorporated into a model using goal programming. This model could also evaluate the tradeoff of putting assets into a fund-raising program versus investing them in fixed-income instruments.

The objective function might be evaluated in terms of utility, not money. That is, the "value" of x dollars to an organization may be less than x times the value of one dollar. The organization's board of directors may be asked to decide if the utility function should be "risk-taking" or "risk-avoiding."

A sociological analysis of why an individual gives might be explored. Experiments can test the effects of such variables as the time of year the solicitation letters are sent, the length of the letters, and the amount of "personalization" in the text of the letters.

The findings might be applied to other organizations so that their executive officers, boards, and members would better understand the nature of evaluating fund-raising alternatives.

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APPENDIX

APPENDIX

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00010  REM  THIS PROGRAM USES R. HOWARD'S POLICY ITERATION
00020  REM  VALUE DETERMINATION ALGORITHM WITH DISCOUNTING TO
00030  REM  FIND THE OPTIMUM ALTERNATIVE FOR EACH STATE IN THE SYSTEM.
00080  REM  ********************
00090  REM PUT THE INITIAL P(I,J) AND R(I,J) VALUES
00092  REM FOR EACH ALTERNATIVE IN LINES 900-999.
00095  REM  ********************
00100  REM THE NUMBER OF ROWS IN A IS EQUAL TO THE TOTAL
00110  REM NUMBER OF ALTERNATIVES.  A HAS ENOUGH COLUMNS
00120  REM TO TAKE THE P-VALUES AND THE R-VALUES FOR ONE
00130  REM ALTERNATIVE.
00135  REM  ********************
00140  REM MATRIX Q IS A COLUMN VECTOR GIVING THE EXPECTED
00150  REM IMMEDIATE REWARD FOR EACH ALTERNATIVE.  IT HAS 1 COLUMN
00160  REM AND A NUMBER OF ROWS EQUAL TO THE NUMBER OF ALTERNATIVES.
00170  REM  ********************
00175    DIM A(25,16)
00176   PRINT "INPUT THE DISCOUNT FACTOR ";
00177   INPUT D
00180  PRINT "INPUT THE NUMBER OF STATES.";
00190  INPUT N
00200  MAT T = ZER(N,1)
00210  MAT B = ZER(N,N)
00220  MAT L = ZER(N,1)
00230  MAT M = ZER(N,1)
00240  MAT F = ZER(N,1)
00250  FOR K = 1 TO N
00260    PRINT "INPUT NUMBER OF ALTERNATIVES FOR STATE "K;
00270    INPUT R(K)
00280    N1 = N1+R(K)
00290  NEXT K
00300  MAT A = ZER(N1,(2*N))
00315  MAT Q6 = ZER(N1,1)
00320  MAT READ A
00330  PRINT
00335  MAT Q = ZER(N1,1)
00340  PRINT "MATRIX A - THE P AND R MATRIX"
00350  PRINT
00360  MAT T = L
00380  PRINT
00390  FOR K = 1 TO N1
00400  FOR J = 1 TO N
00410  X(J) = A(K,J)*A(K,(J+N))
00420  Q(K,1) = Q(K,1)+X(J)
00430  NEXT J
00434   IF UZ = 0 THEN 438
00435   Q(K,1) = (D*Q(K,1)) + Q6(K,1)
00436     GOTO 440
00438   Q(K,1) = Q(K,1) + Q6(K,1)
00440  NEXT K
00442  IF UZ > 0 THEN 450
00444  MAT Q6 = Q
00450  MAT Q3 = TRN(Q)
00460  PRINT "VECTOR OF TEST VALUES"
00470  PRINT
00490  K2 =0
00500  FOR K = 1 TO N
00510    FOR K1 = 1 TO R(K)
00520    K2 = K2+1
00530    P(K,K1) = Q(K2,1)
00540    P1(K,K1) = K2
00550    NEXT K1
00560      FOR J = 1 TO R(K)
00570        FOR K3 = 1 TO R(K)
```

```
00580         IF P(K,J)<P(K,K3) THEN 610
00590         NEXT K3
00600         GOTO 620
00610       NEXT J
00620       L(K,1) = J
00630       M(K,1) = P1(K,J)
00640       F(K,1) = Q6(M(K,1),1)
00650 NEXT K
00660 FOR I = 1 TO N
00670   FOR J = 1 TO N
00680     B(I,J) = A((M(I,1)),J)
00690   NEXT J
00700 NEXT I
00710 PRINT
00720 U7 = U7+1
00730 PRINT 'POLICY IMPROVEMENT RESULTS FOR STEP' U7
00740 PRINT
00750 PRINT '      DECISION MATRIX'
00760 MAT PRINT L;
00770 PRINT
00780 PRINT '      MATRIX OF P-VALUES'
00800 PRINT
00810 PRINT '      MATRIX OF Q-VALUES'
00830 K7 = 0
00840 K8 = 0
00850 FOR J = 1 TO N
00860   K7 = K7+T(J,1)
00870   K8 = K8+L(J,1)
00880 NEXT J
00890 IF K7 = K8 THEN 1350
00895 GOTO 1000
00910  REM DATA FROM TAU BETA PI FUND-RAISING PROBLEM
00920  REM P(8,8), R(8,8), 25 ALTERNATIVES,A(25,16), Q(25,1)
00930   DATA .37,.59,0,.02,0,0,0,.02,49.68,-.14,0,19.68,0,0,0,-.39
00931   DATA .73,.22,0,.03,0,0,0,.02,76.64,-2.48,0,21.64,0,0,0,-2.48
00932   DATA .75,.22,0,.01,0,0,0,.02,70.63,-2.51,0,21.61,0,0,0,-2.51
00940   DATA .05,.88,.0,.05,0,0,0,.02,49.68,-.14,0,17.68,0,0,0,-.39
00941   DATA .11,.81,0,.06,0,0,0,.02,48.33,-.79,0,17.33,0,0,0,-1.04
00942   DATA .13,.81,0,.04,0,0,0,.02,44.53,-3.61,0,15.51,0,0,0,-3.61
00950   DATA 0,0,0,.45,.54,0,0,.01,0,0,0,12.68,-.14,0,0,-.39
00951   DATA .01,0,0,.49,.49,0,0,.01,48.49,0,0,13.49,-.63,0,0,-.88
00952   DATA .015,0,0,.485,.49,0,0,.01,47.48,0,0,13.46,-.66,0,0,-.91
00953   DATA .01,0,0,.42,.56,0,0,.01,48.82,0,0,15.32,-.3,0,0,-.55
00960   DATA .01,0,0,.65,.33,0,0,.01,49.68,0,0,15.18,-.14,0,0,-.39
00961   DATA .03,0,0,.72,.24,0,0,.01,48.58,0,0,14.58,-.54,0,0,-.79
00962   DATA .04,0,0,.71,.24,0,0,.01,47.57,0,0,13.55,-.57,0,0,-.82
00963   DATA .02,0,0,.68,.29,0,0,.01,48.82,0,0,15.82,-.3,0,0,-.55
00970   DATA 0,0,0,.1,.88,0,0,.02,0,0,0,14.68,-.14,0,0,-.39
00971   DATA 0,0,0,.18,.8,0,0,.02,0,0,0,14.82,-.3,0,0,-.55
00972   DATA .01,0,0,.17,.8,0,0,.02,47.35,0,0,13.33,-.79,0,0,-1.04
00980   DATA 0,0,0,0,0,.995,0,.005,0,0,0,0,0,0,0,0
00981   DATA 0,0,.01,0,0,.97,0,.02,0,0,11.68,0,0,-.14,0,-.39
00982   DATA 0,0,.02,0,0,.96,0,.02,0,0,13.57,0,0,-.55,0,-.8
00983   DATA 0,0,.0065,0,0,.9735,0,.02,0,0,4.52,0,0,-.18,0,-.8
00990   DATA 0,0,.03,0,0,.94,0,.03,0,0,9.68,0,0,-.14,0,-.39
00991   DATA 0,0,.03,0,0,.94,0,.03,0,0,11.57,0,0,-.55,0,-.8
00992   DATA 0,0,.04,0,0,.95,0,.01,0,0,12.32,0,0,-.98,0,-1.23
01000   DATA 0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0
```

```
01010  MAT B1 = ZER(N,N)
01020  FOR I = 1 TO N
01030  FOR J = 1 TO N
01040  IF I = J THEN 1070
01050   B1(I,J) = -B(I,J)*D
01060  GOTO 1080
01070   B1(I,J) = 1 - (D*B(I,J))
01080  NEXT J
01090  NEXT I
01100  J = N
01140  MAT B2 = ZER(N,1)
01150  MAT B4 = INV(B1)
01160  MAT B2 = B4*F
01170  MAT B3 = ZER(N,1)
01180  MAT B3 = B2
01200  PRINT "VALUE DETERMINATION RESULTS FOR STEP" U7
01210  PRINT
01220  PRINT "VECTOR OF V-VALUES"
01230  MAT PRINT B3;
01240  PRINT
01270  REM *** REVISE A MATRIX***
01280  FOR I = 1 TO K2
01290  FOR J = (N+1) TO (2*N)
01300  K = (J-N)
01310  A(I,J) = B3(K,1)
01320  NEXT J
01330  NEXT I
01340  GOTO 330
01350  PRINT "NO CHANGE IN DECISION MATRIX"
01360  END
*
```

```
INPUT THE DISCOUNT FACTOR  ?.95
INPUT THE NUMBER OF STATES. ?8
INPUT NUMBER OF ALTERNATIVES FOR STATE  1   ?3
INPUT NUMBER OF ALTERNATIVES FOR STATE  2   ?3
INPUT NUMBER OF ALTERNATIVES FOR STATE  3   ?4
INPUT NUMBER OF ALTERNATIVES FOR STATE  4   ?4
INPUT NUMBER OF ALTERNATIVES FOR STATE  5   ?3
INPUT NUMBER OF ALTERNATIVES FOR STATE  6   ?4
INPUT NUMBER OF ALTERNATIVES FOR STATE  7   ?3
INPUT NUMBER OF ALTERNATIVES FOR STATE  8   ?1

MATRIX A - THE P AND R MATRIX


VECTOR OF TEST VALUES


POLICY IMPROVEMENT RESULTS FOR STEP 1

     DECISION MATRIX


 2

 2

 3

 2

 2

 1

 1

 1
```

VALUE DETERMINATION RESULTS FOR STEP 1

VECTOR OF V-VALUES

348.134

221.248

140.593

156.529

121.596

0

4.15399

[illegible]

POLICY IMPROVEMENT RESULTS FOR STEP 2

DECISION MATRIX

3

3

3

3

3

3

[illegible]

VALUE DETERMINATION RESULTS FOR STEP 2

VECTOR OF V-VALUES

361.414

237.533

159.307

176.413

141.712

51.2981

33.8497

0

POLICY IMPROVEMENT RESULTS FOR STEP 3

DECISION MATRIX

3

3

3

3

3

3

3

1

MATRIX OF P-VALUES

MATRIX OF Q-VALUES

NO CHANGE IN DECISION MATRIX

```
      REAL SUMAMT(8,8,9),AMOUNT(9),SUMCAT(8),
     1     PERCEN(8)
      INTEGER NUMBER(8,8,9),GIFTMO(9),
     1         GIFTYR(9),CLASSY,YEAR,COUNTE,FIRSTY,
     1         MAJOR/1/,LAPSMA/2/,FRITIM/3/,RENEWD/4/,LAPSOU/5/,
     1         NONDON/6/,NEW/7/,DEAD/8/,CLOSTA,LABEL(8)
      COMMON NUMBER,SUMAMT
      READ (5,4) (LABEL(L),L=1,8)
    4 FORMAT (8A4)
          DO 7 III = 1,9
                  DO 5 II2 = 1,76
    5             CONTINUE
                  DO 6 II3 = 1,8
                  DO 6 II4 = 1,8
                  NUMBER(II3,II4,III) = 0
                  SUMAMT(II3,II4,III) = 0.
    6             CONTINUE
    7     CONTINUE
      CUTOFF = 50.
C         READ IN A DATA CARD THE FORMAT IS:
C               COL 1-2      CLASS YEAR
C               COL 3-5      DATE GIFT MADE
C               COL 6-12     AMOUNT OF GIFT
C               THE GIFT DATES AND AMOUNTS OF SUBSEQUENT GIFTS FOLLOW
C               ON THE CARD IN THE SAME FORMAT
   10 READ (5,11,END=110) CLASSY ,(GIFTMO (I),GIFTYR(I),AMOUNT(I),I=1,8)
   11 FORMAT (I2,7(I1,I2,F7.2),I1,I2,F5.0)
   12 COUNTE  = 1
      OLDSTA = NEW
C         IDENTIFY THE FIRST YEAR A MEMBER WAS SOLICITED
          IF (CLASSY  .LT. 72) FIRSTY  = 1
          IF (CLASSY  .EQ. 72) FIRSTY  = 2
          IF (CLASSY  .EQ. 73) FIRSTY  = 3
          IF (CLASSY  .EQ. 74) FIRSTY  = 4
          IF (CLASSY  .EQ. 75) FIRSTY  = 5
          IF (CLASSY  .EQ. 76) FIRSTY  = 6
          IF (CLASSY  .EQ. 77) FIRSTY  = 7
          IF (CLASSY  .EQ. 78) FIRSTY  = 8
C         FIND THE STATES THE MEMBER IS IN FOR EACH YEAR HE OR SHE IS SOLICITED
      DO 100 YEAR = FIRSTY ,8
C         A GIFT GIVEN IN JANUARY OF A YEAR IS CREDITED TO THE PREVIOUS YEAR
      IF (GIFTMO(COUNTE) .EQ. 1) GIFTYR(COUNTE) = GIFTYR(COUNTE) - 1
C         IF A GIFT HAS BEEN GIVEN IN THE CURRENT YEAR, RECORD IT
                  IF (GIFTYR(COUNTE) .EQ. YEAR + 71) GO TO 50
C         NO GIFT WAS RECEIVED IN THE CURRENT YEAR
                  CALL NOGIFT(OLDSTA ,YEAR,CLOSTA )
      GIFTMO(COUNTE) = 5
                  GO TO 100
   50             CALL GIFT(GIJ,OLDSTA ,AMOUNT(COUNTE ),CUTOFF,
     1                              YEAR,CLOSTA ,CLASSY )
                  COUNTE = COUNTE + 1
  100             CONTINUE
      GO TO 10
C         WRITE THE TRANSITION MATRICES FOR THE YEARS EXAMINED
  110 DO 200 K = 1971,1978
          KPLUS1 = K + 1
      WRITE (6,300) K,KPLUS1
```

```
      WRITE (6,5001)
      WRITE (6,5002)
         NEWYR = K - 1970
                  DO 180 L = 1,8
C                              FIND NUMBER IN CATEGORIES AT YEAR'S BEGIN.
                  SUMCAT(L) = 0.
                              DO 170 MM = 1,8
                              SUMCAT(L) = SUMCAT(L) + NUMBER(L,MM,NEWYR)
 170                          CONTINUE
C                 WRITE TRANSITION MATRIX OF ABSOLUTE NUMBERS
                  WRITE (6,175) LABEL(L),(NUMBER(L,J,NEWYR),J=1,8)
 175              FORMAT (1H0,3X,A4,3X,8(I4,6X))
 180              CONTINUE
C                       WRITE TRANSITION MATRIX OF PERCENTAGES
      WRITE (6,5003)
      WRITE (6,5001)
      WRITE (6,5002)
                        DO 195 LL = 1,8
                        DO 194 MMMM = 1,8
                        IF (SUMCAT(LL) .EQ. 0.0) GO TO 191
                        PERCEN(MMMM) = NUMBER(LL,MMMM,NEWYR)/SUMCAT(LL)
                       GO TO 194
 191                    PERCEN(MMMM) = 0.0
 194                    CONTINUE
                  WRITE (6,192) LABEL(LL),(PERCEN(J),J=1,8)
 192              FORMAT(1H0,3X,A4,6X,8(F6.3,4X))
 195                    CONTINUE
      WRITE (6,5004)
      WRITE (6,5005)
      WRITE (6,5007)
C         COMPUTE AND WRITE AVERAGE GIFT SIZES
      DO 1000 LLL = 1,8
              IF (NUMBER(LLL,1,NEWYR) .EQ. 0) GO TO 1001
              TOMAJ = SUMAMT(LLL,1,NEWYR)/NUMBER(LLL,1,NEWYR)
              GO TO 1003
 1001         TOMAJ = 0.0
 1003         IF ( NUMBER(LLL,3,NEWYR) .EQ. 0) GO TO 1002
              TODONR = SUMAMT(LLL,3,NEWYR)/NUMBER(LLL,3,NEWYR)
                    GO TO 1004
 1002         TODONR = 0.0
 1004                IF (NUMBER(LLL,4,NEWYR) .EQ. 0) GO TO 1007
                     TORENW = SUMAMT(LLL,4,NEWYR)/NUMBER(LLL,4,NEWYR)
              GO TO 1005
 1007                TORENW = 0.0
 1005     WRITE(6,1201) LABEL(LLL),TOMAJ,TODONR,TORENW
 1201     FORMAT(1H0,23X,A4,4X,F7.2,5X,F7.2,5X,F7.2)
 1000 CONTINUE
 200      CONTINUE
 5000 FORMAT(1H1,5X'ABSOLUTE NUMBERS GOING FROM ONE STATE TO ANOTHER FOR
     1 YEAR ',I4,' TO ',I4)
 5001 FORMAT(1H ,12X,'MAJOR     LAPSED   1ST-TIME   RENEWED   LAPSED
     1 NON-     NEW     DEAD OR')
 5002 FORMAT(1H ,12X,'DONOR          MAJOR      DONOR      DONOR      DONOR
     1 DONOR    MEMBER     LOST')
 5003                  FORMAT(1H0,//35X,'TRANSITION MATRIX')
 5004 FORMAT(1H1,33X,'REWARD MATRIX COMPONENTS'/)
 5005 FORMAT(1H ,33X,'MAJOR     1ST-TIME  RENEWED')

 5007 FORMAT(1H ,33X,'DONOR        DONOR      DONOR')
      STOP
      END
```

```
      SUBROUTINE GIFT (*,OLDSTA ,VALUE,CUTOFF,YEAR,NEWSTA ,CLASSY )
      REAL ADJCST(8)
      INTEGER MAJOR/1/,LAPSMA/2/,FRTTIM/3/,RENEWD/4/,LAPSOD/5/,
     1        NONDON/6/,NEW/7/,DEAD/8/,OLDSTA,
     1        CLASSY,YEAR
      COMMON NUMBER(8,8,9),SUMAMT(8,8,9)
C        IF ONE WANTS TO TAKE INFLATION INTO ACCOUNT, ASSIGN
C        CONSUMER PRICE INDEX VALUES TO ADJCST(JJ) FOR JJ EQUAL TO 1 THROUGH 8
         DO 10 JJ = 1,8
         ADJCST(JJ) = 1.0
 10      CONTINUE
C        THE MEMBER WILL NO LONGER BE SOLICITED BECAUSE HE OR SHE IS
C        DEAD OR HAS A BAD ADDRESS
      IF ( VALUE .EQ. 0. .OR. VALUE .EQ. -1.) GO TO 200
C        SEE IF THE DONOR HAS CONTRIBUTED ENOUGH TO BE CONSIDERED A
C        MAJOR DONOR
      ADJVAL = ADJCST(YEAR) * CUTOFF
      IF (VALUE .GE. ADJVAL) GO TO 100
      IF (OLDSTA .EQ. NONDON .OR. OLDSTA .EQ. NEW) GO TO 50
C         ADD TO THE TALLY OF RENEWED DONORS
      NUMBER (OLDSTA,RENEWD,YEAR) = NUMBER(OLDSTA,RENEWD,YEAR) + 1
      SUMAMT(OLDSTA,RENEWD,YEAR) = SUMAMT(OLDSTA,RENEWD,YEAR) + VALUE
C         THE CURRENT STATE IS NOW RENEWED DONOR
      NEWSTA = RENEWD
      RETURN
C         ADD TO THE TALLY OF FIRST-TIME DONORS
 50   NUMBER (OLDSTA,FRTTIM,YEAR) = NUMBER (OLDSTA,FRTTIM,YEAR) + 1
      SUMAMT (OLDSTA,FRTTIM,YEAR) = SUMAMT (OLDSTA,FRTTIM,YEAR) + VALUE
C         THE CURRENT STATE IS NOW FIRST-TIME DONOR
      NEWSTA = FRTTIM
      RETURN
C         ADD TO THE TALLY OF MAJOR DONORS
 100  NUMBER(OLDSTA ,MAJOR,YEAR) = NUMBER(OLDSTA ,MAJOR,YEAR) + 1
      SUMAMT (OLDSTA ,MAJOR,YEAR)  = SUMAMT (OLDSTA ,MAJOR,YEAR) + VALUE
C         THE CURRENT STATE IS NOW MAJOR DONOR
      NEWSTA = MAJOR
      RETURN
C         ADD TO THE TALLY OF DECEASED OR BAD ADDRESSES
C         READ IN NEXT DATA CARD
 200  NUMBER(OLDSTA ,DEAD,YEAR) = NUMBER(OLDSTA ,DEAD,YEAR) + 1
      RETURN1
      END
```

```
      SUBROUTINE NOGIFT(OLDSTA ,YEAR,NEWSTA )
      INTEGER MAJOR/1/,LAPSMA/2/,FRTIIM/3/,RENEWL/4/,LAPSDO/5/,
     1         NONDON/6/,NEW/7/,DEAD/8/,OLDSTA,
     1         CLASSY,YEAR
      COMMON NUMBER(8,8,7),SUMAMT(3,5,7)
C         THE NEW STATE DEPENDS ON PAST STATE. IF A MEMBER IS
C         A PREVIOUS CONTRIBUTOR HE OR SHE WILL BE IN A LAPSED STATE
C         RATHER THAN A NONDONOR STATE
      GO TO (10,20,30,40,50,60,70,80),OLDSTA
   10 NUMBER(OLDSTA ,LAPSMA ,YEAR)=NUMBER(OLDSTA ,LAPSMA ,YEAR) + 1
      NEWSTA = LAPSMA
      RETURN
   20 NUMBER(OLDSTA ,LAPSMA ,YEAR) = NUMBER(OLDSTA ,LAPSMA ,YEAR) + 1
      NEWSTA = LAPSMA
      RETURN
   30 NUMBER(OLDSTA ,LAPSDO ,YEAR) = NUMBER (OLDSTA ,LAPSDO ,YEAR) + 1
      NEWSTA = LAPSDO
      RETURN
   40 NUMBER(OLDSTA ,LAPSDO ,YEAR) = NUMBER (OLDSTA ,LAPSDO ,YEAR) + 1
      NEWSTA = LAPSDO
      RETURN
   50 NUMBER(OLDSTA ,LAPSDO ,YEAR) = NUMBER(OLDSTA ,LAPSDO ,YEAR) + 1
      NEWSTA = LAPSDO
      RETURN
   60 NUMBER(OLDSTA ,NONDON ,YEAR) = NUMBER(OLDSTA ,NONDON ,YEAR) + 1
      NEWSTA = NONDON
      RETURN
   70 NUMBER(OLDSTA,NONDON,YEAR) = NUMBER(OLDSTA,NONDON,YEAR) + 1
      NEWSTA = NONDON
      RETURN
   80 NUMBER(OLDSTA,DEAD,YEAR) = NUMBER(OLDSTA,DEAD,YEAR) + 1
      NEWSTA = DEAD
      RETURN
      END
```

ABSOLUTE NUMBERS GOING FROM ONE STATE TO ANOTHER FOR YEAR 1972 TO 1973

	MAJOR DONOR	LAPSED MAJOR	1ST-TIME DONOR	RENEWED DONOR	LAPSED DONOR	NON-DONOR	NEW MEMBER	DEAD OR LOST
MAJD	4	0	0	1	0	0	0	0
LAPM	0	0	0	0	0	0	0	0
1STT	0	0	0	97	95	0	0	3
RENW	0	0	0	0	0	0	0	0
LAPS	0	0	0	0	0	0	0	0
NOND	0	0	101	0	0	1251	0	0
NEW	0	0	0	0	0	67	0	0
DEAD	0	0	0	0	0	0	0	0

TRANSITION MATRIX

	MAJOR DONOR	LAPSED MAJOR	1ST-TIME DONOR	RENEWED DONOR	LAPSED DONOR	NON-DONOR	NEW MEMBER	DEAD OR LOST
MAJD	0.500	0.375	0.0	0.125	0.0	0.0	0.0	0.0
LAPM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1STT	0.0	0.0	0.0	0.497	0.487	0.0	0.0	0.015
RENW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAPS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NOND	0.004	0.0	0.074	0.0	0.0	0.922	0.0	0.0
NEW	0.0	0.0	0.082	0.0	0.0	0.918	0.0	0.0
DEAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

REWARD MATRIX COMPONENTS

	MAJOR DONOR	1ST-TIME DONOR	RENEWED DONOR
MAJD	50.00	0.0	25.00
LAPM	0.0	0.0	0.0
1STT	0.0	0.0	14.66
RENW	0.0	0.0	0.0
LAPS	0.0	0.0	0.0
NOND	112.00	13.88	0.0
NEW	0.0	7.50	0.0
DEAD	0.0	0.0	0.0

ABSOLUTE NUMBERS GOING FROM ONE STATE TO ANOTHER FOR YEAR 1973 TO 1974

	MAJOR DONOR	LAPSED MAJOR	1ST-TIME DONOR	RENEWED DONOR	LAPSED DONOR	NON-DONOR	NEW MEMBER	DEAD OR LOST
MAJD	2	0	0	1	0	0	0	0
LAPM	0	3	0	0	0	0	0	0
1STT	0	0	0	40	65	0	0	2
RENW	2	0	0	70	26	0	0	0
LAPS	1	0	0	20	71	0	0	0
NOND	2	0	73	0	0	1243	0	0
NEW	0	0	12	0	0	88	0	0
DEAD	0	0	0	0	0	0	0	0

TRANSITION MATRIX

	MAJOR DONOR	LAPSED MAJOR	1ST-TIME DONOR	RENEWED DONOR	LAPSED DONOR	NON-DONOR	NEW MEMBER	DEAD OR LOST
MAJD	0.222	0.667	0.0	0.111	0.0	0.0	0.0	0.0
LAPM	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0
1STT	0.0	0.0	0.0	0.374	0.607	0.0	0.0	0.019
RENW	0.020	0.0	0.0	0.714	0.265	0.0	0.0	0.0
LAPS	0.011	0.0	0.0	0.242	0.747	0.0	0.0	0.0
NOND	0.002	0.0	0.055	0.0	0.0	0.943	0.0	0.0
NEW	0.0	0.0	0.122	0.0	0.0	0.878	0.0	0.0
DEAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

REWARD MATRIX COMPONENTS

	MAJOR DONOR	1ST-TIME DONOR	RENEWED DONOR
MAJD	50.00	0.0	25.00
LAPM	0.0	0.0	0.0
1STT	0.0	0.0	13.67
RENW	50.00	0.0	14.74
LAPS	50.00	0.0	17.61
NOND	75.00	11.40	0.0
NEW	0.0	7.92	0.0
DEAD	0.0	0.0	0.0

```
00010   REM  THIS PROGRAM CALCULATES THE CHI-SQUARE
00020   REM  STATISTIC FOR A CONTINGENCY TABLE.
00030   REM  ONE LISTS THE COMPONENTS OF THE TABLE IN THE
00040   REM  DATA SECTION AND IS ASKED TO SUPPLY THE NUMBER
00050   REM  OF ROWS AND COLUMNS IN THE INPUT SECTION.
00100   PRINT "INPUT THE NUMBER OF COLUMNS";
00200   INPUT N1
00201   PRINT "INPUT THE NUMBER OF ROWS";
00202   INPUT N
00300   DIM A(7,3)
00305   MAT READ A
00400   FOR I = 1 TO N
00500   FOR J = 1 TO N1
00600   R(I) = A(I,J) + R(I)
00700   C(J) = A(I,J) + C(J)
00800   S = S + A(I,J)
00900   NEXT J
01000   NEXT I
01100   FOR I = 1 TO N
01200   P(I) = R(I)/S
01300   NEXT I
01301   FOR J = 1 TO N1
01302   Q(J) = C(J)/S
01303   NEXT J
01400   FOR I = 1 TO N
01500   FOR J = 1 TO N1
01600   H = (P(I) * Q(J) * S)
01700   X = (((A(I,J) - H) ** 2)/H) + X
01701   NEXT J
01702   NEXT I
01800   PRINT "THE CHI SQUARE VALUE IS" X
01801   GOTO 2700
02000   DATA 106,1324,0
02100   DATA 112,1403,0
02200   DATA 754,850,1
02300   DATA 398,587,6
02400   DATA 391,697,9
02500   DATA 387,643,12
02600   DATA 340,613,17
02700   END

INPUT THE NUMBER OF COLUMNS ?3
INPUT THE NUMBER OF ROWS ?7
THE CHI SQUARE VALUE IS 1131.17


TIME:  0.08 SECS.

READY
```

VITA

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