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# MIGRATION DECISIONS OF RURAL PHYSICIANS, SASKATCHEWAN, 1978-79

by


(C) MICHAEL A. GORMLEY


A THESIS

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## ABSTRACT

On a per capita basis, fewer Saskatchewan physicians have located in rural than in urban areas. This has led to concerns over the access of the rural population to health care and, ultimately, to government policies aimed at redistributing the stock of physicians.

To properly evaluate these policies, a complete understanding of the migration decisions of individual physicians is required. This study attempts to enhance this understanding by modelling the probability that a physician leaves a rural community over the course of a one year period.

Chapter II provides background information on Saskatchewan. The financing of medical services is discussed along with various aspects of the geographic distribution of physicians and government policies designed to effect that distribution.

Chapter III presents the migration model. A number of variables, related to characteristics of physicians and the areas in which they practiced, were assumed to have a causal relationship with the probability that the physician relocates his practice. The choice of these variables, and the specification of their hypothesized impacts on the probability of relocation, were made according to the human capital approach to migration. The mathematical relationship between the dependent and independent variables was then assumed to follow the binary logistic model.

Chapter IV discusses the data collected for the study. Two samples of physicians were drawn, one each for 1978 and 1979. Data on each observation was then gathered, largely from confidential files maintained by the Saskatchewan Medical Care Insurance Commission and the Saskatchewan Hospital Services Plan.

Chapter V presents the statistical results. Using maximum likelihood estimation, the model was fitted twice to the 1978 sample; once for physicians of all ages and once for physicians between the ages of 30 and 60. The ability of the model to predict migration decisions was then assessed using the 1979 sample.

The results suggest that the independent variables do pick up some of the variation in the probability of relocation. Individual tests of the variables, however, were disappointing. For the model fitted to data on physicians of all ages, only four of the seventeen variables showed up as significant when tested at the five percent level. These variables were associated with the physician's age, family structure, and place of graduation.

Chapter VI illustrates the application of the migration model to questions of public policy. Unfortunately, no hard policy recommendations can be tendered owing to the weak statistical results. It is felt, however, that the general approach taken in the study has merit and that further research in the area is warranted.

## ACKNOWLEDGEMENTS

A number of organizations and individuals provided the necessary support required for the completion of this study. Of particular note was the contribution of the Saskatchewan Medical Care Insurance Commission for its financial support and in providing the bulk of the data employed in the study. Individual contributions by the Commission employees are also acknowledged. Thanks to Mr. Gerry Patchett, Executive Director; Mr. Kelly Scobie, Programmer Analyst with the Statistical Management and Evaluation Branch; and Mr. Peter Lawrence of the Executive Branch. A very special thanks to Mr. Darrell Thomson, Director of the Statistical Management and Evaluation Branch, for his moral support and for commenting on earlier drafts of the study.

Data was also provided by the Saskatchewan Hospital Services Plan. The data request was supported by Mr. George Loewen, Executive Director of the Plan, and complied with under the direction of Mr. Ed Steppan, Director of Registrations.

Early on in the analysis, problems were encountered in the programming of the principle statistical technique employed in the study. These were resolved through conversations with Dr. Richard Shillington, formerly with the Policy Research and Management Services Branch of Saskatchewan Health. Dr. Shillington also answered numerous questions of a statistical nature. It is hoped that the high quality of the responses are accurately reflected.

Several individuals provided articles or references pertinent to the study. Mr. Lothar Rehmer, Health and Welfare Canada, and Mr. Douglas Angus, Statistics Canada, were of particular help in this regard. A special thanks to Dr. Murray Brown, Dalhousie University, for allowing me to review his preliminary work on the location decisions of physicians in Nova Scotia. His work predates my own and, in many ways, served as a guide to the general approach taken in this study.

My interest in economics was stimulated through my association with Dr. Takashi Tsushima of the University of Alberta. The personal interest he has taken both during my years as a student and afterwards was a major factor in the completion of the study.

The contribution of my thesis supervisor, Dr. Richard Plain, is also acknowledged. Dr. Plain's understanding of the Canadian medicare system and health economics in general added immeasurably to my own. Thanks also to Doctors Al W. Jenkins and Gerry Hill who served as committee members for my thesis defence.

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# CHAPTER I

## INTRODUCTION

If past experience is any guide, approximately fifteen percent of Saskatchewan's rural physicians will, over the course of the next year, cease to practice in the community in which they are presently located.[1] This phenomenon is examined within this study, with the focus being on the individual's decision to migrate.

The underlying motivation for the study was to provide a basis for evaluating public policies aimed at redistributing the present stock of physicians. Interest in these policies has been largely derived from the observation that, on a per capita basis, fewer physicians have located in rural than urban areas.[2] This implies that rural populations have been relatively disadvantaged in terms of their access to medical care. It follows that physician relocation is of interest because

> ...any public policy aimed at achieving a more equitable distribution of physicians must focus on those factors which influence the individual physician's decision to migrate. The unique nature of medical services requires either that patients be moved to an area in which physicians are relatively abundant or that physicians move to areas where they are relatively scarce. Of these alternatives, long term preventative patient care would be achieved most economically through physician emigration.[3]

There are two elements to the argument above. First, a geographic maldistribution of physicians was assumed. Second, it was assumed that the study of physician migration decisions can be of assistance in formulating public policies aimed at alleviating that maldistribution. Both of these elements require careful consideration.

## The Geographic Maldistribution of Physicians

The disparity in physician manpower between rural and urban areas cannot be equated to an under- or oversupply of physicians in either area. Any redistribution of resources is justified only if, at the margin, there are net benefits to be gained from the transfer. This potential for gain has not been established so that, strictly speaking, attempts at redistribution cannot be justified on the grounds of efficient resource allocation.

The above implies a need for a cost-benefit analysis of physician services. A supplementary issue, therefore, is whether or not any indicators of economic shortage can be usefully applied to the health system. The answer is probably no, because of two characteristics of the Canadian medical marketplace.

Firstly, as the direct price of medical services is zero,[4] there is no mechanism to force consumers to reveal their true preferences. The Canadian health system encourages persons to capture the benefits of medical services while ignoring the monetary costs of their consumption decisions.[5]

Secondly, the physician acts both as the producer of medical services and as the consumer's agent in advising what services should be obtained. This opens up the possibility of demand generation, ie. the manipulation of consumer preferences by physicians. It has been argued that this leads to a distortion of traditional measures of economic shortage.[6]

In summary, while the popular opinion of researchers and policy makers is that there is a geographic maldistribution of physicians,[7] this has not been, and probably cannot be, established. That it is a widely held belief does not add anything to its veracity.

## The Distribution of Physicians and Public Policy

Leaving the question of the existence of a shortage aside, the argument for more rural physicians still suffers. Even if the shortage is assumed, it does not follow that the answer to the problem lies in the attraction and retention of physicians. The analysis is limited, therefore, as alternative responses are not considered. These would include, for example, the use of physician substitutes or steps to increase the productivity of physicians already in rural areas.[8]

At the same time, however, it should be noted that the fee-for-service physician has served as the principle point of entry to the Canadian health system, with only tentative movements having been made away from this dominance.[9] It would appear, therefore, that future attempts to improve access to health care will continue to concentrate on physicians.[10]

Given this bias, the approach taken in this study has an important role to play in the evaluation of public policy. The results cannot indicate whether or not a given policy is justified in economic terms, but they may prove useful in evaluating the policy's potential for meeting its stated objectives.[11]

## When To Go; Where To Go

There are two, interdependent, aspects of the migration decision--the decisions to go and where to go. As this study only examines the first aspect, the question arises as to whether such an analysis can provide useful information to policy makers. It may be argued, for example, that most policies aimed at redistributing physicians are attempts at attraction, not retention. Interest then centers on why physicians choose particular locations, not why they leave them. There are three responses to this argument.

Firstly, analyzing why physicians leave rural communities may suggest policies aimed at attracting physicians. The decision to stay in a given community is an indicator of the relative attractiveness of the area in much the same way as was the initial decision to locate in the area.

Secondly, policies aimed at attracting physicians are often dependent on the retention of physicians if they are to be effective. A case in point is the Medical Practice Establishment Program (1978),[12] currently in place in Saskatchewan. The program provides grants of up to $5,000 per year, for three years, to physicians locating in certain rural communities. Obviously, the program will be most cost effective if physicians tend to stay in the community after the grants have run out.

Thirdly, there may be some benefits to having a physician stay in a single community, rather than having a succession of physicians over the same time period. For many communities, continuity of care may be a more important problem than actually having to make do without a physician.[13]

<u>Summary</u>

The study of physician migration decisions has been proposed as a useful tool for the evaluation of public policies aimed at redistributing the current stock of physicians. This statement of purpose was then conditioned by two factors. First, it was pointed out that the gains of physician redistribution have never been clearly established and, as such, represents one of the assumptions of the study. Second, it was suggested that even if there is a geographic maldistribution of physicians, the answer to the problem need not necessarily lie in the attraction and retention of physicians. Other alternatives, such as the use of physician substitutes, may be more cost effective.

In the last section, it was noted that the approach taken in the study--ie. of examining the decision to stay in or leave a rural community--is only a partial analysis of the migration decision. For a number of reasons, however, the results of the study can still be expected to provide useful information to policy makers.

## FOOTNOTES TO CHAPTER I

[1]The source for this statement is table II.2 of this study.

[2]For example, refer to table II.1 of this study which compares the geographic distribution of physicians with that of the general population for Saskatchewan.

[3]F. J. Navratil and J. J. Doyle, "The Migration Decision of Physicians: A Microanalytic Approach," in Socioeconomic Issues of Health, 1978, eds. J. L. Werner and J. R. Leopold (Chicago: American Medical Association, 1978), p. 121.

[4]Provided, of course, that there is no extra-billing.

[5]J. L. Migué and G. Bélanger, The Price of Health (Toronto: Macmillan of Canada, 1974), pp. 202-14.

[6]R. G. Evans, "Does Canada Have Too Many Doctors--Why Nobody Loves An Immigrant Physician," Canadian Public Policy 2 (1976): 147-60.

[7]Refer, for example, to J. R. Evans, "Health Manpower: Issues and Goals in Canada," in Pan American Conference on Health Manpower Planning (Washington: Pan American Health Organization) pp. 35-43; M. Le Clair, "The Canadian Health System," in National Health Insurance: Can We Learn From Canada?, ed. S. Andreopoulos (New York: John Wiley and Sons, Inc., 1975), p. 88, and L. Soderstrom, The Canadian Health System (London: Croom Helm, 1978), p. 117.

[8]Several papers which deal with increasing the productivity of physicians are presented in J. Rafferty, Health Manpower and Productivity (Lexington: Lexington Books, 1974).

[9]The dominant role of the physician as the point of entry to the Canadian health system was extensively dealt with in a brief to the Hall Commission by the Canadian Nurses Association. The major points have been summarized in E. M. Hall, Canada's National-Provincial Health Program for the 1980's (Ottawa: Queen's Printer, 1980), pp. 74-8.

[10]It is difficult to predict exactly what direction the future course of health manpower policy will take. It is interesting to note, however, the view of Wolfe and Badgley:

> The most costly use of personnel and facilities consume most of the health care dollar, and equally effective and possibly more economical alternatives are damned with faint praise, or

opposed or left to wither as interesting but a typical experiment. /Attributed to Wolfe and Badgley in ibid., p. 74./

[11]The distinction made here does not exist if it is assumed that the preferences of consumers are reflected in government policy. As has been stated elsewhere, this is an heroic assumption. /Migué and Bélanger, The Price of Health, p. 214./

[12]Saskatchewan, "Medical Practice Establishment Regulations, 1979" (reg. no. 90/79, "Health Services Act," Revised Statutes of Saskatchewan, chap. H-1.) See also subsequent amendments reg. nos. 269/79, 62/80, and 236/80.

[13]This has been the case in Saskatchewan. Refer to chap. II, f.15 of this study.

Note that the suggestion here is that there are costs to having a physician leave a community which are independent of whether or not another physician immediately takes up practice in the area. If this is indeed the case, then these costs are likely to be higher for rural than urban communities owing to their higher population - physician ratios. Physician relocation then becomes of public interest in its own right and not simply because of its ultimate impact on the geographic distribution of physicians.

# CHAPTER II

## PHYSICIAN MANPOWER IN RURAL SASKATCHEWAN

The purpose of this chapter is to provide background information for the study of physician migration. This includes discussions of

1) the funding of physician services,

2) the geographic distribution of physicians,

3) the relocation rates of physician manpower, and

4) government policies which have attempted to influence the location decisions of physicians.

### Funding of Medical Services in Rural Saskatchewan

The Saskatchewan Medical Care Insurance Commission (S.M.C.I.C.) served as the primary source of data for the study. Therefore, a brief discussion[1] of the operations of the Commission is in order.

Established in 1962 under the Saskatchewan Medical Care Insurance Act (1961),[2] S.M.C.I.C. provides comprehensive coverage for most physician services and for some dental, optometric, and chiropractic services. All residents are eligible for benefits except

1) beneficiaries of the Swift Current Health Region,

2) persons covered under other federal or provincial programs (eg. members of the R.C.M.P.), and

3) persons residing in the province less than three months who were previously beneficiaries of a medicare plan in another province.[3]

The plan is financed through general revenues and contributions made by the federal government under federal-provincial cost sharing arrangements.[4] During 1978 and 1979, the time period selected for the study of physician migration, no premiums or user charges were levied.

Physicians may charge in excess of the S.M.C.I.C. Schedule of Benefits, but this amount is the responsibility of the patient.

The physicians operating under S.M.C.I.C. are paid on a fee-for-service basis. There are, however, a number of alternative methods of payment. Physicians may

1) submit claims and be directly reimbursed by S.M.C.I.C., or

2) submit claims to an approved health agency who pays the physician and is subsequently reimbursed by S.M.C.I.C., or

3) submit claims to patients who pay the physician and are subsequently reimbursed by S.M.C.I.C.

Only S.M.C.I.C. physicians were included in the analysis of physician migration. There are, however, three other agencies which fund physician services in rural Saskatchewan.

1) The Swift Current Health Region (S.C.H.R.) has administered a health services insurance plan, similar to S.M.C.I.C.'s, since 1946.[5] While an important part of the province's health care system, only a small proportion of residents are beneficiaries of the S.C.H.R. During 1980, for example, the breakdown was 4.2 percent under the S.C.H.R. and 95.8 percent under S.M.C.I.C.[6]

2) The Department of Northern Saskatchewan contracts physicians to provide services in isolated northern areas of the province. During the 1979/80 fiscal year, three full-time physicians were located in the clinic at Ile-a-la-Crosse. In addition, several physicians in private practice were contracted to make regular visits to clinics in other northern communities.[7]

3) Health and Welfare Canada funds a portion of the medical services provided to treaty Indians living on reserves. This includes paying the

salaries of physicians operating out of a 57 bed hospital in the town of Fort Qu'Appelle.[8]

## Geographic Distribution of Physicians

Table II.1 compares the geographic distribution of S.M.C.I.C. physicians with that of the plan's beneficiaries. During the late seventies, rural areas (populations under 10,000)[9] accounted for 55 percent of beneficiaries but only 45 percent of general practitioners. This translates to 49 percent more persons per physician in rural areas.[10]

The unevenness of the distribution becomes more pronounced if two factors are taken into account.

Firstly, patients in the cities of Regina, Saskatoon, and Prince Albert have access to physicians under contract to the province's community clinics.[11] Therefore, levels of urban physician manpower are understated when only fee-for-service physicians are considered.

Secondly, approximately 99 percent of fee-for-service specialists locate in urban centers.[12] Taking all fee-for-service physicians into account, the population-physician ratio was approximately 90 percent higher in rural than in urban areas during the late seventies.

One of the problems with the comparison provided in table II.1 is that it involves simple head counts of physicians. This type of analysis can be misleading in so far as rural physicians may be more, or less, productive than urban physicians. To the extent that rural physicians are more productive, a simple head count exaggerates the maldistribution of physicians. Conversely, the maldistribution is understated if rural physicians are less productive than urban physicians.

The simplest approach to resolving the problem cited above is to

TABLE II.1 : RURAL/URBAN BREAKDOWN OF BENEFICIARIES AND PHYSICIANS

SASKATCHEWAN MEDICAL CARE INSURANCE COMMISSION, 1970-80

| YEAR | BENEFICIARIES RURAL | BENEFICIARIES URBAN | ACTIVE PHYSICIANS: GENERAL PRACTICE RURAL | ACTIVE PHYSICIANS: GENERAL PRACTICE URBAN | ACTIVE PHYSICIANS: ALL PHYSICIANS RURAL | ACTIVE PHYSICIANS: ALL PHYSICIANS URBAN |
|---|---|---|---|---|---|---|
| | (%) | (%) | (%) | (%) | (%) | (%) |
| 1970 | 60.4 | 39.6 | 52.5 | 47.5 | 31.6 | 68.4 |
| [illegible] | 60.0 | 40.0 | 51.7 | 48.3 | 31.5 | 68.5 |
| 1972 | 59.5 | 40.5 | 51.8 | 48.2 | 31.8 | 68.2 |
| 1973 | 59.2 | 40.8 | 49.8 | 50.2 | 30.6 | 69.4 |
| 1974 | 58.5 | 41.5 | 48.8 | 51.2 | 30.0 | 70.0 |
| 1975 | 57.7 | 42.3 | 47.9 | 52.1 | 30.8 | 69.2 |
| 1976 | 57.5 | 42.5 | 48.1 | 51.9 | 30.9 | 69.1 |
| 1977 | 57.2 | 42.8 | 48.2 | 51.8 | 31.3 | 68.7 |
| 1978 | 57.0 | 43.0 | 47.0 | 53.0 | 29.9 | 70.1 |
| 1979 | 56.9 | 43.1 | 45.3 | 54.7 | 28.8 | 71.2 |
| 1980 | 56.6 | 43.4 | 44.7 | 55.3 | 28.6 | 71.4 |

NOTES :
1) RURAL/URBAN SPLIT :
RURAL - COMMUNITIES WITH FEWER THAN 10,000 RESIDENTS .
URBAN - COMMUNITIES WITH 10,000 OR MORE RESIDENTS .
2) PHYSICIAN COUNTS : PHYSICIANS RESIDING IN THE PROVINCE, OUTSIDE THE SWIFT CURRENT HEALTH REGION, AT THE END OF THE YEAR WHO RECEIVED ATLEAST THE FOLLOWING IN S.M.C.I.C. PAYMENTS :
1970-77 - $ 10,000
1978-80 - $ 20,000

SOURCE :
1) SASKATCHEWAN MEDICAL CARE INSURANCE COMMISSION ANNUAL REPORTS (VARIOUS YEARS).
2) SASKATCHEWAN HOSPITAL SERVICES PLAN COVERED POPULATION (VARIOUS YEARS).

compare the percentage of payments going to rural and urban general practitioners. In 1978, for example, only 43.0 percent of general practitioners were located in rural areas but they accounted for 48.9 percent of general practitioner payments.[13] Therefore, the simple head count does tend to overstate the geographic maldistribution of physicians. Nonetheless, the general picture remains the same, the percentage of S.M.C.I.C. beneficiaries in rural areas (57%) being less the percentage of payments going to rural general practitioners.

Rates of Relocation

Rural communities not only have problems attracting physicians, they also have problems keeping them. Of the 265 general practitioners active[14] in a rural community during 1978, 16.6 percent had changed their place of practice by the end of 1979. The corresponding relocation rate for urban areas was only 6.3 percent. As would be expected, this difference is statistically significant when tested at the 5.0 percent level (table II.2).

It should be noted that the high rate of relocation does not imply that smaller communities were net losers of physicians. As illustrated in table II.2, the distribution of general practitioners by community size were very similar for 1978 and 1979. In fact, 119 of the 120 communities with an active physician in 1978 still had an active physician at the end of 1979.[15]

Government Policies

Given the uneven geographic distribution and the high rates of relocation for rural physicians, there are two options open to the government.

The first option is to do nothing. This can be justified on the

TABLE II.2 : NUMBER OF PHYSICIANS CHANGING THEIR PRIMARY LOCATION, 1978 AND 1979

| PRIMARY LOCATION ON DECEMBER 13 | 1978 NUMBER ACTIVE | 1978 CHANGED LOCATION IN 1979 | 1978 LOSS RATE(%) | 1979 NUMBER ACTIVE | 1979 CHANGED LOCATION IN 1980 | 1979 LOSS RATE(%) |
|---|---|---|---|---|---|---|
| 1. RURAL AREAS | | | | | | |
| POP : 5,000 + | 44 | 9 | 20.5 | 42 | 2 | 4.8 |
| POP : 2,500-4,999 | 67 | 6 | 9.0 | 63 | 9 | 14.3 |
| POP : 1,000-2,499 | 79 | 15 | 19.0 | 79 | 12 | 15.2 |
| POP : 500-999 | 59 | 6 | 10.2 | 57 | 8 | 14.0 |
| POP : 250-499 | 24 | 8 | 33.3 | 26 | 8 | 30.8 |
| POP : LESS THAN 250 | 4 | 2 | 50.0 | 4 | 1 | 25.0 |
| TOTAL FOR RURAL AREAS | 277 | 46 | 16.6 | 271 | 40 | 14.8 |
| 2. URBAN AREAS | | | | | | |
| REGINA | 104 | 7 | 6.7 | 108 | 4 | 3.7 |
| SASKATOON | 105 | 7 | 6.7 | 113 | 9 | 8.0 |
| OTHER URBAN AREAS | 91 | 5 | 5.5 | 87 | 6 | 6.9 |
| TOTAL FOR URBAN AREAS | 300 | 19 | 6.3 | 308 | 19 | 6.2 |
| ALL LOCATIONS | 577 | 65 | 11.3 | 579 | 59 | 10.2 |

NOTES : 1) 'ACTIVE PHYSICIANS' : RESIDING IN THE PROVINCE, OUTSIDE THE SWIFT CURRENT HEALTH REGION, ON DECEMBER 31 AND RECEIVED OVER $5,000 IN S.M.C.I.C. PAYMENTS DURING THE FOURTH QUARTER OF THE YEAR .

2) CHI SQUARE TEST HO : INDEPENDENCE OF MOBILITY AND RURAL/URBAN LOCATION

| YEAR | TEST STATISTIC | CONFIDENCE LEVEL | CRITICAL VALUE | REJECT HO ? |
|---|---|---|---|---|
| 1978 | 15.215 | 95.0 % | 3.841 | YES |
| 1979 | 12.177 | 95.0 % | 3.841 | YES |

SOURCE: S.M.C.I.C. PHYSICIAN MOBILITY FILE .

grounds that either the present situation is acceptable or that the system will rectify any problems. The latter argument is based on the assumption that the decreasing population per physician ratio, which has been observed in all provinces,[16] will eventually force physicians to locate in rural areas. Some evidence for this was found by Roos et al.,[17] but most analysts would agree with Evans' statement that physicians

> ...may be in the wrong places, and doing the wrong things relative to what the public or planners would prefer, but increasing their numbers will not help this problem.[18]

The second option is to adopt programs aimed at attracting and/or retaining physicians. The Saskatchewan Government's efforts in this regard are described below.

1) <u>The Medical Scholarship and Bursaries Act (1963)</u>[19]

Enacted in 1963, the program was orginally designed to assist students in meeting the high costs of medical school. The Act was modified in 1973 in order to provide incentives to new graduates to locate inside the province, especially in areas of greatest need.

Payments made under the Act were in units of $500. Students, most of whom were enrolled in the College of Medicine at the University of Saskatoon,[20] were eligible for a maximum of five units per year.

Once the recipients had completed their education, the loan was repayable at 9.25 percent interest p.a. or through service in Saskatchewan. The rate of repayment was one or two units per six months of service, depending on whether the physician located in an area of physician need. A strict definition of "need" was never set, the issue being decided on a case by case basis.

The program was discontinued in March of 1979. It is difficult to evaluate the success of the program, as it is not known what would have happened in its absence. However, it would be difficult to argue that it had a significant impact on the distribution of physicians. In 1973, the first year of the modified program, there were 91 graduates of the University of Saskatchewan practicing as general practitioners in the province of which 49.5 percent were located in rural areas. By 1979, the last year of the program, the percentage practicing in rural areas had dropped to 35.7 percent.[21] During the same time period, the percentage of S.M.C.I.C. beneficiaries in rural areas also dropped, but only from 59.2 percent in 1973 to 56.9 percent in 1979 (table II.1).

2) The Medical Practice Establishment Program (1979)[22]

This program was designed to assist communities in attracting Canadian-trained physicians not currently practicing in the province. Matching grants are provided, with a number of expenditures being eligible for the community's contribution. These include direct cash payments to physicians or expenditures for the building or maintenance of clinics.

For the purposes of the program, "communities" are defined as union hospital districts or other geographical areas approved by the Minister of Health. To be eligible for grants, communities

1) must not contain a municipality with a population exceeding 5,000, and

2) must either contain a location with a hospital or which, customarily, has had a full-time physician.

While considerable funds are available, up to $15,000 per physician over a three year period, the program has had only limited success. As of the end of the 1980/81 fiscal year only four physicians received grants and three of these established practice in a single town.[23]

3) Other Policies

Aside from the specific legislation mentioned above, two other vehicles have been used in Saskatchewan to attract physician manpower.

a) Licensing of Foreign Graduates[24]

Up until September 1981, Saskatchewan maintained reciprocal licensing agreements with most Commonwealth countries. This represented one of the more liberal licensing arrangements, most other provinces requiring all foreign graduates to obtain the Licentiate of the Medical Council of Canada.[25] The requirements were stiffened somewhat in 1981, Commonwealth graduates now being required to obtain their Canadian licensure within three years of starting practice in the province.

The effect of Saskatchewan's licensing policies has been to encourage foreign graduates to locate in the province. Saskatchewan now depends on these graduates for over 50 percent of its physician manpower, second only to Newfoundland.[26] Foreign graduates also represent a disproportionate share of the province's rural physicians, a point that will be discussed at greater length in chapter VI.

b) Local Initiatives

Several communities provide incentives designed to attract physicians. These include, for example, the provision of housing and office facilities. A description of some of these initiatives may be found in the study of rural practices conducted by the University of Saskatchewan.[27]

Summary

This chapter has provided background information for the study of physician migration. The financing of medical services was discussed along with various aspects of the geographic distribution of physicians and government policies designed to effect that distribution. Of particular note were the urban concentration of physician manpower and the high rate of relocation from rural communities.

The remainder of the study concentrates on the migration decisions of rural physicians. This includes discussions of i) the specification of the migration model (chapter III), ii) the sampling criterion and the data collected for the study (chapter IV), iii) the statistical results obtained from the model (chapter V), and iv) the conclusions reached in the study (chapter VI).

FOOTNOTES TO CHAPTER II

[1]For a more complete description, refer to Saskatchewan Medical Care Insurance Commission, Annual Report (Regina: Queen's Printer, various years). Hereafter cited as S.M.C.I.C., Annual Report.

[2]Saskatchewan, "Saskatchewan Medical Care Insurance Act," Revised Statutes of Saskatchewan," chap. S-29.

[3]Persons moving from one province to another are covered by the province of departure for the first three months.

[4]For a description of federal cost sharing arrangements refer to Soderstrom, The Canadian Health System, pp. 140-2.

[5]For a description of the S.C.H.R. refer to Saskatchewan Health (Policy Research and Management Services Branch), History of the Swift Current Health Region Medical Care Plan (Regina: Saskatchewan Health, 1969).

[6]S.M.C.I.C., Annual Report 1978, p. 27.

[7]Department of Northern Saskatchewan, Annual Report 1979/80 (Regina: Queen's Printer, 1980), p. 9.

[8]Outside of Fort Qu'Appelle and surrounding area, most services to Indians are provided by S.M.C.I.C. fee-for-service physicians.

[9]The primary reason for this choice of the rural/urban cutoff was that it corresponds to that used by S.M.C.I.C. in its various statistical reports. Using the same cutoff greatly facilitated various aspects of the study.

[10]The percentage difference in the population/physician ratio can be calculated as,

$$\left\{\left[\frac{\text{\% Population Rural}}{\text{\% Physicians Rural}}\right] \div \left[\frac{\text{\% Population Urban}}{\text{\% Physicians Urban}}\right] - 1\right\} 100$$

[11]For a description of the community clinics refer to D. Gruending, The First Ten Years (pamphlet prepared at the request of the Board of Directors of the Community Health Services Association, 1974).

[12]In 1978, for example, there were 319 specialists practicing in the province, of which only 3 were located in a rural area. Refer to S.M.C.I.C., Annual Report 1978, p. 49.

[13] S.M.C.I.C. Annual Report 1978, pp. 46-7.

[14] Active physicians were those who received over $5,000 in S.M.C.I.C. payments during the last quarter of the year and were located in the province, outside the Swift Current Health Region, on December 31.

[15] The number of Saskatchewan locations with at least one active physician in 1978 or 1979 is given below.

| At least on G.P. in 1978? | At least one G.P. in 1979? | |
|---|---|---|
| | Yes | No |
| Yes | 119 | 1 |
| No | 4 | N/A |

[16] Health and Welfare Canada (Policy, Planning and Information Branch), Canada Health Manpower Inventory, 1978 (Ottawa: Health and Welfare Canada, 1979) p. 181.

[17] N. P. Roos, M. Gaumont, and J. M. Horne, "The Impact of the Physician Surplus on the Distribution of Physicians Across Canada," Canadian Public Policy 2(1976): 169-91.

[18] R. G. Evans, "Health Services in Nova Scotia--The View from the Graham Report," Canadian Public Policy 1(1975): 364.

[19] Saskatchewan, "Medical Scholarship and Bursaries Act," Revised Statutes of Saskatchewan, chap. M-11.

[20] If budgetted funds were still available, bursaries were provided to students attending medical schools outside the province.

[21] S.M.C.I.C., Annual Report (various years).

[22] Saskatchewan, "Medical Practice Establishment Grant Regulations, 1979."

[23] Saskatchewan Health, Annual Report 1980/81 (Regina: Queen's Printer, 1981), p. 6.

[24] Saskatchewan, "Medical Professions Act, 1981," Revised Statutes of Saskatchewan, chap. M-10.1.

[25] Soderstrom, The Canadian Health System, pp. 77-9.

[26] Health and Welfare Canada, Canada Health Manpower Inventory, pp. 188-93.

[27] M. P. Sarich, ed., Medical Practice in Saskatchewan (Saskatoon: The College of Medicine, University of Saskatchewan, 1976).

CHAPTER III

## METHODOLOGY: THE MODEL

This chapter sets out the research hypotheses regarding the probability of physician relocation. These took three major forms, namely,

1) variable selection (the choice of variables assumed to have causal relationship with the decision to stay or leave),

2) variable impact (the assumed direction of impact of the independent variables on the probability of relocation), and

3) econometric specification (the assumed mathematical relationship between the dependent and independent variables).

### Variable Selection

Variable selections were based on the human capital approach to migration. In brief, the theory states that migration occurs whenever there are net benefits to be gained. Benefits include higher expected lifetime incomes and increased access to cultural and other facilities. Costs include the direct costs of moving (realtor fees, moving expenses, etc.), the risk that prior expectations will not be met, and the psychic costs of leaving family and friends.[1]

Given its central role in the study it is important that the evidence regarding the human capital approach be reviewed. This evidence has taken two forms which, for lack of a better terminology, shall be denoted as direct and indirect.

#### 1. Direct Evidence[2]

The direct approach assumes that income is the most important factor in the migration investment decision and that prior expectations of gain have some basis in reality. Verification of the theory, therefore, rests on finding significantly higher incomes for migrants when compared to non-migrants. Some past studies which have taken this approach are discussed below.

a) Beck and Stabler[3] compared changes in income for movers and stayers within Saskatchewan.[4] Comparisons were controlled for by age, sex, and location (rural, town, or city).

Positive returns to migration were found for moves to more urbanized locations. Moves to less urbanized locations resulted in a loss of income while intra-rural, town, or city moves showed no consistent pattern.

b) Grant and Vanderkamp[5] compared the 1971 incomes of persons who moved once during the period 1965-71 with those who did not. The comparison was controlled for by 1965 income, age, sex, marital status, labour market experience, and 1971 location. Migrants were differentiated in the earnings function[6] according to whether the move took place early (prior to 1969) or late in the period and whether it was short (under 100 miles) or long.

The final results provided only weak support for the human capital approach. On average, long distance-early movers were earning only $250 more than stayers during 1971 and long distance-late movers were earning $530 less. Assuming that the negative payoff lasts for a single year, this translates to the present value of a long distance move being $1,970 when a 10 percent discount rate is used. The authors note that this is considerably lower than previous estimates.[7]

c) Marr and Millerd[8] compared the 1971 incomes of persons residing inside and outside of the province in which they finished their formal education. The comparison was controlled for by age, sex, family structure, place of birth, education, language spoken, class of worker, and weeks worked.

The results suggested a migration payoff in the order of $565. This is double the return that was suggested in the Grant and Vanderkamp study. The reason for this difference may be that migration payoffs take a considerable length of time to come into effect. This conclusion is supported by another comparison by Marr and Millerd where the definition of movers was restricted to persons changing provinces during the period 1966-71. In this case, no significant difference was found between the 1971 incomes of movers and stayers.[9]

2. Indirect Evidence[10]

The indirect approach assumes that, if the theory is correct, migrants should favour regions with the greatest economic advantages. For example, the rate of migration from province i to province j should be negatively related to the average income in i and positively related to the average income in j. These hypotheses are then modelled and tested. No attempt is made to ascertain whether migration is a good investment, the hallmark of the direct approach.

a) Courchene, Foot and Milne, Laber and Chase, and Vanderkamp[11] have all considered the rates of migration between provinces as a function of the comparitive economic conditions. Though the studies varied considerably in model specification and variable choice, they have all reported results consistent with the human capital approach to migration.

b) In some preliminary work, Brown[12] analyzed the location decisions of physicians entering practice in Nova Scotia during the years 1969 to 1973. The comparison was between physicians locating inside and outside the Halifax-Dartmouth metropolitan area. The results provided support for the human capital model in two ways.

Firstly, non-metro areas which received physicians had, on average, higher medicare payments per physician than metro areas. If benefits are derived from metropolitan living, then this result is consistent with the human capital approach.

Secondly, all other things being equal, Dalhousie graduates were more likely to locate in Halifax-Dartmouth. Given their years of schooling in the area, this result is consistent with the hypothesis that leaving familiar surroundings represents one of the costs of moving.

c) Hadley[13] hypothesized that a province's equilibrium supply of physicians was a function of the average physician's net income and the province's medical education facilities. In addition, it was assumed that adjustments to new equilibriums would not be automatic. Rather, a standard partial adjustment mechanism was employed.

The results suggested that income plays a significant role in explaining inter-provincial variations in physician supply. An increase of one percent in net income will lead to a .5 percent increase in supply in the short run and a 3.3 percent increase in the long run.[14]

d) Mathematica Policy Research[15] compared the rates of physician immigration for 65 market areas in Quebec.[16] Among other variables, the migration model included average earnings, rate of population growth, and the physician-population ratio.

Concentrating on the results for general practitioners, the support for the human capital model was mixed. The effect of average income was of the expected sign (positive) and significant. The effect of population growth was also of the correct sign but insignificant. Finally, the physician-population ratio was of the wrong sign and significant. With regards to this last result, the authors hypothesize that either physicians do not weigh the supply ratio in their location decisions or that they derive some benefit through associations with other physicians.[17]

In summary, there is a great deal of evidence to support the investment approach to migration. Therefore, it was felt that this model provided a strong basis for variable selection. The expected impact of these variables, which measured characteristics of physicians and the areas in which they practiced, were then specified in a manner consistent with the human capital approach.

The actual list of the dependent variables included in the migration model will be dealt with in the next section. In general, however, variable selections were based on the following assumptions:

1) The opportunities for practice in alternative locations were equal for all physicians included in the study.

2) The costs of moving to alternative locations were equal for all physicians included in the study.

3) Validity of the human capital approach to migration.

Given the validity of assumptions 1) and 2), then the expected migration payoff will be negatively related to the income which a physician can expect to receive if he stays in a single location. Along with assumption 3), this implies that the probability of relocation will increase as the economic potential of a physician's current location decreases.

Obviously, the equal opportunities and costs of migration assumptions are difficult to defend. Two aspects of the study, however, helped to adjust for this deficiency.

Firstly, there was a large degree of homeogeneity in the sample of physicians, ie. general practitioners who were actively practicing in rural Saskatchewan at the end of a given year. Sampled physicians were, therefore, operating under similar circumstances. These included, for example, the use of a single fee schedule and a general lack of competition for patients from physicians of other specialties.[18]

Secondly, independent variables, other than those directly related to the economic potential of the physician's location at the start of the study period, were included in the analysis. For example, the expected migration payoff will decline with age as older physicians have fewer years in which to earn income in a new location. Including the age of the physician in the analysis helped account for this factor.

Another issue regarding variable selection was the measurement of "economic potential." The most obvious choice would have been the level of S.M.C.I.C. payments made to the physician. Unfortunately, this variable cannot be considered as independent from the other variables included in the analysis. Rather, the observed level of S.M.C.I.C. payments would be the result of a complex interaction of the physician's demand for income (leisure) and the demands of consumers for his services. Including S.M.C.I.C. payments, therefore, would have required a more complicated model than that envisioned for this study.

In response to the problem cited above, independent measures of economic potential were added to the migration model. These included, for example, the population-physician ratio of the area in which the physician was located. This, it was hypothesized, provided a measure of economic potential independent of such factors as the physician's age and the length of time the physician had been in the area.

Variable Impact

The definitions of the independent variables assumed to have a causal relationship with the probability of relocation are provided in table III.1. Readers interested in a more detailed discussion are referred to appendices A (Detailed Descriptions for the Independent Variables) and B (Comment on Data Sources).

This section goes through the list of independent variables and states their hypothesized impacts on the migration decision. Variables expected to be negatively related to the probability of relocation are indicated by a minus sign (-) after the variable name. Conversely, variables expected to be positively related are indicated by a plus sign (+). It should also be noted that all hypotheses are stated ceteris paribus.

1. AGE (-)

The probability of relocation was expected to decrease as the age of the physician increased. This was hypothesized because younger physicians have a greater time period in which to realize returns which outweigh the costs of moving. This assumption has been supported in numerous migration studies.[19]

2. SEX (-)

Several studies have found that migration payoffs for females are less than that for males.[20] Therefore, it was hypothesized that female physicians would be less mobile than male physicians.

With regards to studies of physician migration, the support for this hypothesis is, admittedly, very weak. Navratil and Doyle[21] did find that female physicians were less mobile but this result was not

TABLE III.1 : DESCRIPTIONS FOR THE INDEPENDENT VARIABLES

| VARIABLE LABEL | DESCRIPTION |
|---|---|
| AGE | PHYSICIANS AGE, IN YEARS, ON DEC. 31 OF THE SAMPLE YEAR . |
| | PHYSICIANS SEX : |
| SEX | = 1, FEMALE,<br>= 0, MALE . |
| | FAMILY STRUCTURE : |
| FAM1 | = 1, MARRIED WITH NO CHILDREN UNDER THE AGE OF 18,<br>= 0, OTHERWISE . |
| FAM2 | = 1, MARRIED WITH CHILDREN UNDER THE AGE OF 18,<br>= 0, OTHERWISE . |
| | PLACE OF GRADUATION : |
| GRAD1 | = 1, GRADUATE OF THE UNIVERSITY OF SASKATCHEWAN(OWING ON A BURSARY),<br>= 0, OTHERWISE . |
| GRAD2 | = 1, GRADUATE OF A CANADIAN MEDICAL SCHOOL OUTSIDE SASKATCHEWAN,<br>= 0, OTHERWISE . |
| GRAD3 | = 1, GRADUATE OF A MEDICAL SCHOOL OUTSIDE CANADA,<br>= 0, OTHERWISE . |
| | LENGTH OF TIME IN CURRENT LOCATION : |
| STAY1 | = 1, IN TOWN LESS THAN 1 YEAR,<br>= 0, OTHERWISE . |
| STAY2 | = 1, IN TOWN FROM 1 TO 2 YEARS,<br>= 0, OTHERWISE . |

CONTINUED NEXT PAGE ...

TABLE III.1 CONTINUED

| VARIABLE LABEL | DESCRIPTION |
|---|---|
| PRAC | TYPE OF PRACTICE: = 1, IN AN ASSOCIATED PRACTICE, = 0, IN A SOLO PRACTICE . |
| GROWTH | RATE OF GROWTH OF THE TOWN IN WHICH THE PHYSICIAN IS LOCATED . |
| DIST | DISTANCE FROM TOWN TO THE NEAREST OF REGINA OR SASKATOON (IN KM.'S) . |
| RATIO | DISTRICT POPULATION (RURAL MUNICIPALITY) PER ACTIVE PHYSICIAN IN THE DISTRICT (IN 000'S) . |
| P-ELD | % OF DISTRICT POPULATION OVER 65 . |
| P-TOWN | % OF DISTRICT POPULATION IN THE SAME TOWN AS THE PHYSICIAN . |
| BED1 | LEVEL 6 (ACUTE CARE) HOSPITAL BEDS IN TOWN PER ACTIVE PHYSICIAN . |
| BED2 | LEVEL 1 TO 3 (SUPERVISORY, PERSONAL, & BASIC NURSING CARE) HOSPITAL BEDS IN TOWN PER ACTIVE PHYSICIAN . |

statistically significant. In comparison, Steiber[22] found that females made up a larger proportion of physician movers than stayers. This last result has to be treated with some caution, however, as the migration rates were not controlled for other factors.

3. FAM1 (-), FAM2 (-)

The psychic costs of moving were assumed to increase with family size. Therefore, it was expected that the coefficients of FAM1 (married with no children) and FAM2 (married with children) would both be negative and that the absolute value of the latter would be greater than the former. Some support for this hypothesis was found by Navratil and Doyle[23] who found that married physicians were less mobile than single physicians.

4. GRAD1 (-)

Saskatchewan graduates were identified in the model by two groupings of the place of graduation variables, namely,

a) GRAD1 = GRAD2 = GRAD3 = 0, and

b) GRAD1 = 1, GRAD2 = GRAD3 = 0.

The latter group represents graduates owing on a medical school bursary who cannot retire the debt through one year's service in the province.[24] As movement out of the province would incur the cost of repayment, it was expected that these physicians would be less likely to relocate.

5. GRAD2 (+)

Saskatchewan graduates were expected to be less mobile than other Canadian graduates, the latter group being identified by the binary variable GRAD2. There were three reasons for making this hypothesis.

Firstly, research in the United States has shown that prior exposure increases the probability that a physician will locate in a particular state, the probability increasing with the number of exposure events, ie. birth, medical school, internship, and residency.[25] The result suggests an investment in the area in the form of professional contacts, family, and friends. This investment should also inhibit future mobility, at least to destinations outside the province.

Secondly, other Canadian graduates may be less risk averse than Saskatchewan graduates. The former have already exhibited a willingness to undergo the risks and uncertainties of a long distance move, a characteristic not shared by the latter.

Finally, at least for physicians locating in the province for the first time, it can be assumed that Saskatchewan graduates are better informed as to benefits of locating in a particular area. This increases the chances that prior expectations will be met and should, all other things being equal, decrease the probability of relocation.[26]

6. <u>GRAD3 (?)</u>

GRAD3, a binary variable identifying foreign graduates, can be expected to have a positive coefficient for the same reasons given for the variable GRAD2. There are, however, two reasons why foreign graduates may be less mobile than Saskatchewan graduates.

Firstly, during the period of the study, most foreign graduates were restricted in their migrations to other provinces.[27] Movement to British Columbia or Alberta, for example, would have required that the Licentiate of the Medical Council of Canada be obtained.[28] This constitutes an additional moving expense.

Secondly, foreign graduates may have greater difficulties in establishing practices. This would be the case, for example, if Canadians discriminate in favour of the home product.[29] If foreign graduates can overcome this discrimination with time, then relocation presents an added opportunity cost not faced by their Canadian counterparts.

As a result of these considerations, it was hypothesized that foreign graduates would be less mobile than Canadian graduates. The expected sign of the coefficient of GRAD3, which indicates the relative positions of foreign and Saskatchewan graduates, was not specified a priori.

7. STAY1 (-), STAY2 (-)

Physicians in a location for less than one year (STAY1) or for one to two years (STAY2) were expected to be more mobile than other physicians. Establishing a practice entails considerable monetary and non-monetary costs, so that the opportunity costs of relocation were assumed to be directly related to the length of time in the community.[30] It follows that expected signs of STAY1 and STAY2 are negative and that the absolute value of the STAY1 coefficient should be greater than that for STAY2.

8. PRAC(-)

Evans et al. and Roos have both found that small group practices (two to four physicians) are more productive than solo practices.[31] Assuming that these economies of scale translate to higher net incomes, it was hypothesized that the coefficent of PRAC (= 1 for associated practices; 0 otherwise) would be negative.

There are two other reasons for expecting a negative coefficient for PRAC. First, if physicians place value on professional contacts,[32] then an associated practice will partially fulfill this need. Second, other members of the group can fill in for the physician during periods of absence.

9. DIST (+)

The distance to the nearest of Regina or Saskatoon was included as a measure of the physician's accessability to the province's major medical and cultural centers. It was expected to have a positive sign.

10. GROWTH (-)

The rate of growth of the town in which the physician was located was included as a measure of the general economic health of the area. Towns with relatively high growth rates were expected to have fewer problems keeping physicians.

11. RATIO (-)

The variable RATIO was defined as the population-physician ratio for the rural municipality in which the physician was located. High ratios were expected to lead to larger practices and to the development of queues. The former should increase economic opporutunities while the latter has often been assumed to be a source of utility for physicians.[33] The coefficient of RATIO, therefore, was expected to be negative.

It may be argued that, given the urban concentration of physicians, it is unlikely that rural physicians would suffer from a shortage of patients. The argument, however, is merely an artifact of the data which arises from treating rural areas as a single entity. As shown below, in 1978 the average rural municipality had a physician-population ratio of 1,121:1, with only 616 of these persons living in the same town as the physician. In comparison, the ratio for Regina was 1,531:1.[34] While this last figure drops dramatically when specialist manpower is taken into account, it should be noted that Regina serves as the major referral center for southern Saskatchewan. This is evidenced by days of care data for the city's hospitals. In 1971, for example, 42.9 percent of the days of care for Regina's general hospitals were for non-city residents.[35]

| | Persons/Physician, 1978 | | |
|---|---|---|---|
| | Town/City | Area | Total |
| Rural Municipalities with G.P.'s | 616 | 505 | 1,121 |
| Regina | | | |
| - G.P.'s | 1,531 | -- | 1,531 |
| - G.P.'s & Specialists | 717 | -- | 717 |

A second criticism of the use of the variable RATIO stems from the nature of the medical marketplace. Briefly, as consumers are uncertain as to the benefits of medical care, decisions as to what services should be obtained are often left to the discretion of the physician. This allows physicians to substitute their own preferences, say for higher incomes, for those of consumers.[36]

If the theory of demand generation is correct, then physicians should never be faced with an insufficient demand for their services. Migration decisions, therefore, will not be influenced by the population-physician ratio simply because it has no relation to the economic potential of a physician's practice.

The argument above only holds if demand generation is unbounded and costless. Neither is likely to be the case.[37] First, consumers do have some control over consumption, if only in terms of the initial decision to seek care.[38] Second, unless physicians are neutral to questions of efficacy, there will be a psychic cost associated with providing services of little or no benefit. Third, there is the fear of getting caught. S.M.C.I.C., for example, carries out extensive auditing of physician practices.[39]

In summary, the variable RATIO was included as a measure of the economic potential of the area in which the physician was located. While it was realized that "economic potential" must be interpreted in the light of demand generation, it was assumed that demand generation itself was costly. Therefore, the probability of relocation was expected to decrease as RATIO increased.

12. <u>P-ELD (-)</u>

The high utilization rates of physician services by the elderly has been clearly established.[40] Therefore, the probability of relocation was expected to decrease as the percentage of persons in the rural municipality over the age of 65 (P-ELD) increased.

13. <u>P-TOWN (-)</u>

The demand for medical care has also been related to the distance between consumers and providers.[41] Therefore, the probability of relocation was expected to decrease as the percentage of persons in the same town as the physician (P-TOWN) increased.

In addition, it was found that P-TOWN was highly correlated with the size of the town, with a correlation coefficient of .775.[42] As larger towns tend to have more amenities, this relationship should reinforce the hypothesized relationship between the probability of relocation and P-TOWN.

14. BED1 (-), BED2 (-)

The number of general hospital (BED1) and nursing home (BED2) beds, expressed in per physician terms, were both expected to be negatively related to the probability of relocation. Physicians, in other words, are expected to derive benefits by having access to these facilities. Access to general hospital beds, for example, may allow physicians to provide, what they feel, is a higher quality of care. In addition, there may be some monetary benefits as fewer patients will have to be referred to other centers.

## Econometric Specification

The problem of physician migration was conceived as one of discrimination. Given a list of physicians, what is the best rule for assigning individuals into the mover and stayer populations? The answer to this question is of some interest because

1) an analysis of the decision rule may be useful in determining what factors distinguish movers from stayers, and

2) the decision rule may be useful in predicting future migration decisions.

The above implies that the best rule is of interest, but it does not state what is meant by the best rule. The most general statement is that the best rule minimizes the costs of misclassification.[43]

To illustrate, assume that measurements of the independent variables, AGE...BED2, are available for the set of physicians actively practicing in the province. The objective is to classify physicians into the mover or stayer populations on the basis of these measurements. Defining $R_1$ and $R_2$ as two mutually exclusive regions which exhaust the variable space, physicians are classified as movers if their measurements fall into $R_1$ and as stayers otherwise. The optimal choice for the regions minimizes

$$C(2|1)p_1\int_{R_2} f_1(.)d(.) + C(1|2)p_2\int_{R_1} f_2(.)d(.)$$

where

$C(2|1)$, $C(1|2)$ = respectively, the cost of classifying i) a mover as a stayer and ii) a stayer as a mover,

$p_1$, $p_2$ = respectively, the prior probability that a physician will i) move and ii) stay,

$(.)$ = the independent variables as listed in table III.1, and

$f_1(.)$, $f_2(.)$ = respectively, the probability density functions for the populations of i) movers and ii) stayers.

Noting that

$$\int_{R_1} f_1(.)d(.) + \int_{R_2} f_1(.)d(.) = 1$$

the cost function can be restated as

$$C(2|1)p_1 + \int_{R_1} \{C(1|2)p_2f_2(.) - C(2|1)p_1f_1(.)\}d(.).$$

This function is minimized if

$$C(2|1)p_1f_1(.) > C(1|2)p_2f_2(.)$$

everywhere in $R_1$. This suggests the following classification rule:

1) If

$$\frac{f_1(.)}{f_2(.)} > \frac{C(1|2)p_2}{C(2|1)p_1},$$

classify as a mover.

2) If 1) does not hold, classify as a stayer.

Often the costs of misclassification are not known. In these cases, the usual assumption is that C(2|1) equals C(1|2) and the rule stated above minimizes the total number of misclassifications.

It should be evident that the optimal rule is critically dependent upon the distributions of the variates. This has led to a variety of classification rules being proposed, including

1) Fisher's linear discriminant,[44]

2) logistic discrimination,[45]

3) discrimination based on the location model,[46] and

4) discrimination based on the multinomial model.[47]

Procedures 3) and 4) were discarded because of insufficient data. Use of either of these models would have required considerably larger samples than those available for this study. In choosing between the remaining procedures, two factors were taken into account.[48]

Firstly, the logistic model covers a wider variety of situations. Strictly speaking, Fisher's linear discriminant only applies if the independent variables are distributed multivariate normal with equal variance-covariance matrices for movers and stayers. The logistic model covers this situation and others as well.

Secondly, logistic models are, in certain cases, applicable when the variates contain both binary and continuous variables.[49] Only the latter are permissable when linear discriminants are used.

For these reasons, it was decided that the logistic model would be used. It should be noted, however, that the utility of logistic vis á vis linear discrimination is often overstated. In actual application, the situation will often be that the underlying assumptions of neither procedure strictly hold. The question then becomes one of robustness. Past studies have suggested that the performances of the two procedures are very similar under these circumstances.[50]

Given the binary logistic model, the probability of relocation is given by

$$P = \Pr\{\text{Move} \mid \text{AGE} \ldots \text{BED2}\}$$

$$= \frac{\exp\{\beta_0 + \beta_1 \text{AGE} + \ldots + \beta_{17}\text{BED2}\}}{1 + \exp\{\beta_0 + \beta_1 \text{AGE} + \ldots + \beta_{17}\text{BED2}\}}$$

where

$P$ = the probability that an active physician leaves his December 31 location within one year's time,

AGE...BED2 = the independent variables as listed in table III.1, and

$\beta_0 \ldots \beta_{17}$ = the parameters of the model.

Some properties of the logistic model, which will be of assistance in later discussions, are as follows:

1) The value of P is restricted to the 0 - 1 range.

2) As the physician must either stay in his present location or leave, the probability that he stays is simply (1-P).

3) Using the variable AGE as an example,

$$\frac{\partial P}{\partial \text{AGE}} = \beta_1 P(1-P).$$

Therefore, if $\beta_1$ is greater than zero then the probability of relocation increases with AGE. Alternatively, if $\beta_1$ is less than zero, then the probability of relocation decreases with AGE. The hypothesis regarding whether a variable is positively or negatively related to P can, therefore, be stated in terms of whether the coefficient for the variable is positive or negative.

4) The elasticity of P with respect to AGE is given by,

$$\left|\frac{\partial P}{\partial AGE}\;\frac{AGE}{P}\right| = \left|\beta_1(1-P)AGE\right| .$$

For a given value of AGE, the elasticity approaches its minimum as P approaches one and approaches its maximum as P approaches zero. The greater (lesser) the probability of relocation due to the combined effects of all the variates, the lesser (greater) will be the impact of a one percent increase in a given value of AGE.

## Summary

This chapter has stated the research hypotheses. These included variable selection, the hypothesized impact of each variable on the probability of relocation, and the econometric specification of the migration model.

In general, variable selections were based on the human capital approach to migration. Past studies, some of which were reviewed, suggest that this model provides a strong basis for the investigation of migration decisions.

Hypotheses regarding variable impact were made in a manner consistent with the human capital approach. For example, the human capital approach not only implies that age plays a role in the decision to migrate, but also that the probability of relocation should be negatively related to age.

In terms of econometric specification, the binary logistic model was employed. This represents one of many statistical procedures suitable for dichotomous dependent variables, a brief outline of which were presented.

## FOOTNOTES TO CHAPTER III

[1]L. Sjaastad, "The Costs and Returns of Human Migrations," Journal of Political Economy 70 (1962): 80-93.

[2]The discussion is restricted to Canadian studies. For some American evidence, refer to J. B. Lansing and J. N. Morgan, "The Effect of Georgraphic Mobility on Income," Journal of Human Resources 2 (1967): 449-60.

[3]R. G. Beck and J. C. Stabler, Intra-regional Migration Patterns in Saskatchewan (Saskatoon: University of Saskatchewan, Extension Division, 1974).

[4]The study was limited to persons residing in the province between 1963 and 1968. The migration payoffs of persons leaving the province were not examined.

[5]E. K. Grant and J. Vanderkamp, "The Effects of Migration on Income: A Micro Study with Canadian Data 1965-71," The Canadian Journal of Economics 13 (1980): 381-406.

[6]Both Grant and Vanderkamp and Marr and Millerd use the following model:

$$E_i = \beta_0 + \beta_1 M_i + \beta_2 O_i$$

where

$E_i$ = 1971 earnings,

$M_i$ = a variable, or variables, indicating mobility,

$O_i$ = other factors influencing income, and

$\beta_0, \beta_1, \beta_2$ = the model parameters.

Positive returns to migration are indicated if $\beta_1$ tests as being significantly greater than zero. Refer to Grant and Vanderkamp, "The Effects of Migration on Income" and W. L. Marr and F. W. Millerd, "Employment Income Levels of Inter-Provincial Migrants Versus Non-Migrants, Canada, 1971," in Research in Population Growth, vol. 2, eds. J. L. Simon and J. Da Vanzo (Greenwich: Jai Press, 1980), pp. 43-63.

[7]For example, see J. Vanderkamp, "Migration Flows, Their Determinants and the Effects of Return Migration," Journal of Political Economy 79 (1971): 1012-31.

8 Marr and Millerd, "Employment Income Levels of Inter-Provincial Migrants Versus Non-Migrants, Canada, 1971."

9 This difference between the two studies was noted by Grant and Vanderkamp, "The Effects of Migration on Income."

10 The discussion is restricted to Canadian studies. For some American evidence on the economic determinants of migration, refer to:

a) Inter-regional or state migration--S. Bowles, "Migration as Investment: Empirical Tests of the Human Capital Approach to Geographic Mobility," Review of Economics and Statistics 52 (1970): 356-62; R. L. Kaluzny, "Determinants of Household Migration: A Comparitive Study by Race and Poverty Level," Review of Economics and Statistics 57 (1975): 269-74; and F. J. Navratil and J. J. Doyle, "The Socioeconomic Determinants of Migration and the Level of Aggregation," The Southern Economic Journal 43 (1977): 1547-59.

b) Physician migration and location decisions--L. Benham et al, "Migration, Location, and Remuneration of Medical Personnel: Physicians and Dentists," Review of Economics and Statistics 50 (1968): 332-47; F. J. Navratil and J. J. Doyle, "The Migration Decisions of Physicians: A Microanalytic Approach," in Socioeconomic Issues of Health, 1978, eds. J. L. Werner and J. R. Leopold (Chicago, American Medical Association, 1978) pp. 121-33; and G. V. Rimlinger and H. B. Steele, "An Economic Interpretation of the Spatial Distribution of Physicians in the U.S.," Southern Economic Journal 30 (1963): 1-12.

11 T. J. Courchene, "Inter-Provincial Migration and Economic Adjustment," Canadian Journal of Economics 3 (1970): 550-76; D. K. Foot and W. J. Milne, "Public Policies and Interprovincial Migration in Canada: An Econometric Analysis," (Halifax: paper presented at the Canadian Economics Assocation Meeting, 1981); G. Laber and R. X. Chase, "Inter-provincial Migration in Canada as a Human Capital Investment," Journal of Political Economy 79 (1971): 795-804; and J. Vanderkamp, Mobility Behaviour in the Canadian Labour Force (Ottawa: Economic Council of Canada Special Study No. 16, 1973).

12 M. G. Brown, "Analysis of Physician Location Decisions in Nova Scotia: Choice of First Location," (Halifax: unpublished paper presented to the Nova Scotia Council of Health, 1975).

13 J. Hadley, Financial Incentives and Physician Distribution: Evidence from Canada (Washington: The Urban Institute Working Paper 1225-2, 1979).

14 These results were based on the assumption that only one province experiences an increase in physician incomes.

15 Mathematica Policy Research, A Study of the Response of Canadian physicians to the Introduction of Universal Medical Care Insurance

(Princeton: Mathematica Policy Research, 1977).

[16] The study included models of in, out, and net migration for general practitioners and specialists. The discussion here has been limited to the general practitioner, in migration model.

[17] The benefits of association has been noted in other research. McFarland cites numerous studies which have found that the availability of professional contacts and modern facilities were important factors in the location decisions of physicians. Both of these factors could result in "clustering." Refer to J. McFarland, "Toward an Explanation of the Geographical Location of Physicians in the United States," in Measuring Physician Manpower (Chicago: American Medical Association, 1973), pp. 17-36.

[18] For the rural/urban distribution of specialists, refer to chap. II f.15.

[19] Bowles, "Migration as Investment;" and Kaluzny, "Determinants of Household Migration."

[20] Beck and Stabler, Intraregional Migration Patterns in Saskatchewan; Grant and Vanderkamp, "The Effects of Migration on Income;" and Marr and Millerd, "Employment Income Levels of Inter-Provincial Migrants Versus Non-Migrants, Canada, 1971."

[21] Navratil and Doyle, "The Migration Decisions of Physicians."

[22] S. R. Steiber, "Geographic Mobility of Physicians," in Profile of Medical Practice, 1980, eds. G. L. Glandon and R. J. Shapiro (Chicago: American Medical Association, 1980), pp. 67-78.

[23] Navratil and Doyle, "The Migration Decisions of Physicians."

[24] The Medical Scholarship and Bursaries Act (1963) was described in chapter II. In brief, physicians receiving bursaries while in medical school could either pay back the loan directly or through service in the province.

[25] D. E. Yett and F. A. Sloan, "Migration Patterns of Recent Medical School Graduates," Inquiry 11 (1974): 125-42.

[26] On the relationship of prior expectations to subsequent migration, refer to A. Yezer and L. Thurston, "Migration Patterns and Income Changes: Implications for the Human Capital Approach to Migration," Southern Economic Journal 42 (1976): 693-702.

[27]Of the 262 general practitioners practicing in rural areas during 1978, 64 percent were foreign graduates. Of these, 64 percent were from the United Kingdom, Eire, or Australia, all of which had reciprocal licensing agreements with Saskatchewan. A further 28 percent of these graduates were from Asia, most of whom have been licensed under the General Medical Council of Great Britian and would not, therefore, have required the Licentiate of the Medical Council of Canada (L.M.C.C.). In total, therefore, approximately 92 percent of foreign graduates would not have been required to obtain their Canadian licensure (S.M.C.I.C., Annual Report 1978, p. 46).

It should be noted that it was originally intended to differentiate L.M.C.C. and non-L.M.C.C. foreign graduates in the logistic equation. Unfortunately, the S.M.C.I.C. Physician Mobility File (see appendix B) does not appear to be reliable on this score. Most Canadian graduates do not have the L.M.C.C. according to the information on the file.

[28]This information was obtained from unpublished S.M.C.I.C. file.

[29]Some evidence for this was found by Muzondo and Pazerka in their study of professional licensing and its impact on earnings. After adjusting for a number of factors (see pages 106 to 123 of their study), it was found that Canadians earned more than other ethnic and national groups, the differences being significant for Blacks, West Indians, and Asians. Of course, this only provides weak evidence of discrimination. There may, for example, be ethnic variations in the income-leisure trade off. Refer to T. R. Muzondo and B. Pazderka, Professional Licensing and Competition Policy: Effects of Licensing on Earnings and Rates-of-Return Differentials (Ottawa: Bureau of Competition Policy, Research Monograph No. 5, 1979).

[30]Note that there is an implicit assumption here that the physician cannot recapture all of his investment when he sells his practice.

[31]R. G. Evans, E. M. A. Parrish, and F. Sully, "Medical Productivity, Scale Effects and Demand Generation," Canadian Journal of Economics 6 (1973): 376-93 and N. P. Roos, "Impact of the Organization of Practice on Quality of Care and Physician Productivity," Medical Care 18 (1980): 347-59.

[32]Refer, for example, to McFarland, "Toward an Explanation of the Geographic Location of Physicians."

[33]Feldstein, for example, suggested that excess demand allowed physicians to select the most interesting cases. Wolfson et al. went further by suggesting that a large patient load acted as an insurance policy, ie. the larger the patient load the greater the chance that a physician can reach his target income in the future. Refer to M. S. Feldstein, "The Rising Price of Physicians' Services," Review of Economics and

Statistics 52 (1970): 121-33 and A. D. Wolfson, C. J. Tuohy and P. S. Chandrakant, What Do Doctors Do?: A Study of Fee-for-Service Practice in Ontario (Toronto: University of Toronto, Institute for Policy Analysis, 1978).

[34]S.M.C.I.C., Annual Report 1978, p. 49.

[35]Of course, patients may come from outside the rural municipality. This, however, is also true of cities. Clarkson, for example, estimated that the primary service area of Regina was made up of 92 percent city residents and 8 percent non-city residents. Refer to J. C. Clarkson, Health Care Services in Regina (Hamilton: J. Graham Clarkson Consultants, 1973). That rural physicians actually serve fewer persons than urban physicians is also supported by patient count data. In 1978, the average rural G. P. saw 1,940 discrete patients, while the count for urban G.P.'s was 2,070 (S.M.C.I.C. Annual Report 1978, p. 42).

[36]R. G. Evans and A. D. Wolfson, "Moving the Target to Hit the Bullet: Generation of Utilization by Physicians in Canada," (Stanford: paper prepared for the National Bureau of Economic Research Conference, 1978).

[37]All of the following points were raised by Wolfson, Tuohy, and Chandrakant, What Do Doctors Do?, p. 11.

The suggestion here is that there are two aspects of utilization, ie. services generated by patients (the decision to seek care) and those prescribed by doctors. Demand generation only enters into only the second aspect.

[39]The S.M.C.I.C. Audit Group currently employs a staff of seven. They use information from three sources in determining which physicians should receive intensive investigation. These are i) claims rejected by the Claims and Assessment Branch, ii) letters of verification which are regularly sent to all beneficiaries, and iii) the physician profiles which are produced each quarter by the Statistical Management and Evaluation Branch.

[40]M. J. Gross and C. W. Schwenger, Health Care Costs for the Elderly in Ontario: 1976-2026 (Toronto: Ontario Economic Council Occasional Paper No. 11, 1981) and P. Manga, The Income Distribution Effect of Medical Insurance in Ontario (Toronto: Ontario Economic Council Occasional Paper No. 5, 1978).

[41]J. P. Acton, "Non-monetary Factors in the Demand for Medical Care," Journal of Political Economy 83 (1975): 595-614 and P. I. Jehlik and R. L. McNamara, "The Relation of Distance to the Differential Use of Certain Health Personnel and Facilities and to the Extent of Bed Illness," Rural Sociology 17 (1952): 261-65.

[42]Because of this high correlation, it was decided not to include the size of the town as a separate variable.

[43]T. W. Anderson, An Introduction to Multivariate Statistical Analysis (New York: John Wiley and Sons, 1958), pp. 127-30 and P. A. Lachenbruch, Discriminant Analysis (New York: Hafner Press, 1975), pp. 14-5.

[44]R. A. Fisher, "The Use of Multiple Measurements in Taxonomic Problems," Annals of Eugenics 7 (1936): 179-88.

[45]J. A. Anderson, "Separate Sample Logistic Discrimination," Biometrika 59 (1972): 19-36; N. E. Day and O. F. Kerridge, "A General Maximum Likelihood Discriminant," Biometrics 23 (1967): 313-23; and D. R. Cox, "Some Procedures Connected with the Logistic Qualitative Response Curve," in Research Papers in Statistics: Essays in Honour of J. Neyman's 70th Birthday, ed. F. N. David (London: John Wiley and Sons, 1966), pp. 57-71.

[46]W. J. Krzanowksi, "Discrimination and Classification Using Both Binary and Continuous Variables," Journal of the American Statistical Association 70 (1975): 782-90; "Canonical Representation of the Logistic Model for Discrimination and Classification," Journal of the American Statistical Association 71 (1976): 845-8; and "The Performance of Fisher's Linear Discriminant Under Non-Optimal Conditions," Technometrics 19 (1977): 191-200.

[47]M. Goldstein and W. R. Dillon, Discrete Discriminant Analysis (New York: John Wiley and Sons, 1978).

[48]S. J. Press and S. Wilson, "Choosing Between Logistic Regression and Discriminant Analysis," Journal of the American Statistical Association 73 (1978): 699-705.

[49]Lachenbruch, Discriminant Analysis, p. 82.

[50]Krzanowski, "Discrimination and Classification," and Press and Wilson, "Choosing Between Logistic Regression and Discriminant Analysis."

CHAPTER IV

# METHODOLOGY: THE DATA

This chapter describes the data collected for the study. This includes descriptions of the process through which physicians were selected for study and the definitions of the dependent and independent variables.

## The Samples

Two samples of rural physicians were drawn, one for each of 1978 and 1979. The selection criterion, denoted by S1 to S6, were as follows:

S1) Listed as a general practitioner by the Saskatchewan College of Physicians and Surgeons on December 31 of the sample year (ie. 1978 or 1979).

S2) In a rural location (June 30, 1978 population less than 10,000)[1] on December 31 of the sample year, but outside[2] of

a) the Swift Current Health Region,

b) the City of Loydminister, or

c) the Town of Uranium City.

S3) Received over $5,000 in S.M.C.I.C. payments during the fourth quarter of the sample year.[3]

Physicians satisfying conditions S1 through S3 were denoted as being "active" during the fourth quarter of the sample year. For the most part, the samples employed in the study were comprised of these physicians, with the following exceptions:

S4) Physicians dying within one year of the sampling date (December 31) were excluded.[4]

S5) Physicians involuntarily removed from the Register of The

Saskatchewan College of Physicians and Surgeons within one year of the sampling date were excluded.[5]

S6) In cases where a husband and wife satisfied conditions S1 through S3, the physician receiving the lowest level of S.M.C.I.C. payments was excluded.[6]

Readers interested in the rationale for the sampling criterion are referred to the footnotes. With regards to sample size, reference to table IV.1 reveals that 262 physicians satisfied conditions S1 to S3 in 1978, while the corresponding count for 1979 was 255 physicians. Of these, 14 were excluded from the 1978 sample and 10 from the 1979 sample because of conditions S4 through S6. The net results of these additions and deletions were the following:

Sample Size, 1978 = 248 Physicians

Sample Size, 1979 = 245 Physicians

Defining the Dependent Variable: Movers and Stayers

The discussion regarding table II.2 provided a simple measure of mobility. In brief, this measure took the following form:

1) A physician's primary location was defined as his or her location on December 31. If the physician had more than one location, the primary location was defined as that under which the majority of the physician's S.M.C.I.C. payments were received. The remaining locations were designated as "secondary."

2) Using the 1978 sample as an exampl[illegible] [illegible]ers and stayers were defined as,

| | | | |
|---|---|---|---|
| Movers: | December 31, 1978 Primary Location | ≠ | December 31, 1979 Primary Location |
| Stayers: | December 31, 1978 Primary Location | = | December 31, 1979 Primary Location |

TABLE IV.1 : NUMBER OF PHYSICIANS INCLUDED IN THE STUDY

| | 1978 SAMPLE | 1979 SAMPLE |
|---|---|---|
| A)RURAL PHYSICIANS ACTIVE DURING THE FOURTH QUARTER OF THE SAMPLE YEAR (SAMPLING CONDITIONS S1-S3) | 262 | 255 |
| B)ACTIVE PHYSICIANS EXCLUDED FROM THE STUDY (SAMPLING CONDITIONS S4-S6) | | |
| - DEATH (S4) | 1 | 0 |
| - DISIPLINARY ACTION BY COLLEGE (S5) | 1 | 0 |
| - SPOUSE IS IN ACTIVE PRACTICE (S6) | 12 | 10 |
| TOTAL NUMBER OF EXCLUSIONS | 14 | 10 |
| C)TOTAL SAMPLE SIZE | 248 | 245 |

NOTE : COMPLETE DEFINITIONS OF THE SAMPLING CONDITIONS S1 TO S6 ARE GIVEN IN THE TEXT OF THIS THIS CHAPTER .

This resulted in a straight forward definition of mobility with the advantage of being the simplest one to handle on a computer. However, two instances arose where the results could have been misleading.

Firstly, a physician could have moved only a short distance with little or no change in the group of patients under his care. There would have been, in effect, a change in the location of the physician but not in his practice. As the primary concern was with changes in the latter, it was decided to ignore moves under 25 km. All physicians moving less than this distance were treated as stayers.[7]

Secondly, a physician with two or more locations could have switched the emphasis of his practice between locations. This would not represent movement, but it would be measured as such according to the definition given above. To adjust for this, any movements to "secondary" locations were simply ignored for the purposes of defining movers and stayers.[8]

The two conditions mentioned above, along with the previous definition of mobility, permitted classification of each sampled physician as a mover or stayer. The results are presented in table IV.2 and summarized briefly below.

| | 1978 Sample | 1979 Sample |
|---|---|---|
| Movers | 38 | 40 |
| Stayers | 210 | 205 |
| Total | 248 | 245 |

## The Independent Variables

The independent variables employed in the study were defined in table III.1. Readers interested in a more detailed discussion are again

TABLE IV.2 : BREAKDOWN OF SAMPLED PHYSICIANS INTO MOVERS AND STAYERS

| | 1978 SAMPLE | 1979 SAMPLE |
|---|---|---|
| A)MOVERS | | |
| 1)MOVED WITHIN S.M.C.I.C. AREA | | |
| - 25-99 KM. | 1 | 0 |
| - 100 + KM. | 13 | 20 |
| 2)MOVED OUT OF S.M.C.I.C. AREA | | |
| - TO SWIFT CURRENT HEALTH REGION | 0 | 0 |
| - OUT OF PROVINCE | 23 | 20 |
| - DESTINATION UNKNOWN | 1 | 0 |
| TOTAL FOR MOVERS | 38 | 40 |
| B)STAYERS | | |
| 1)NO CHANGE IN PRIMARY LOCATION | 209 | 205 |
| 2)DISTANCE MOVED UNDER 25 KM. | 1 | 0 |
| 3)SWITCHED TO SECONDARY LOCATION | 0 | 0 |
| TOTAL FOR STAYERS | 210 | 205 |
| C)TOTAL SAMPLE SIZE | 248 | 245 |

referred to appendices A and B.

Table IV.3 provides simple summary statistics for each of the independent variables. Of particular interest is the information on missing data. Two approaches to handling these cases were considered, namely,

1) the dropping of any observation with missing values for one or more of the independent variables, and

2) the filling in of any gaps in the data with estimated values.

The relative costs and benefits of these alternatives are discussed in appendix C. In brief, however, any advantage to be gained through the use of the second procedure had to be weighted against any losses arising from errors in measurement, ie. from the differences between the estimated and the actual values for the missing data. With this in mind, estimates for the missing data were obtained and their accuracy evaluated, with the following conclusions:

1) Estimates of AGE - Reliable estimates for the missing values of AGE were obtained and were used in all of the analysis that is reported in later chapters.

2) Estimates of FAM1 and FAM2 - The procedure used in estimating these variables was found to be subject to considerable error. Because of this, most of the analysis made use of only those cases with complete information on family structure.

Fitting the Model

Using maximum likelihood estimation, the logistic model was fitted to the 1978 sample described in chapter III. The ability to predict future migration decisions was then evaluated using the 1979 sample.

Of course, the value of the independent variable is not directly

TABLE IV.3 : DESCRIPTIONS AND SUMMARY STATISTICS FOR THE INDEPENDENT VARIABLES

| VARIABLE LABEL | DESCRIPTION | 1978 SAMPLE MEAN | 1978 SAMPLE S.D. | 1978 SAMPLE MISSING | 1979 SAMPLE MEAN | 1979 SAMPLE S.D. | 1979 SAMPLE MISSING |
|---|---|---|---|---|---|---|---|
| AGE | PHYSICIANS AGE, IN YEARS, ON DEC. 31 OF THE SAMPLE YEAR . | 42.99 | 10.99 | 2 | 43.30 | 11.19 | 2 |
| SEX | PHYSICIANS SEX : = 1, FEMALE, = 0, MALE . | 0.10 | 0.31 | - | 0.09 | 0.29 | - |
| FAM1 | FAMILY STRUCTURE : = 1, MARRIED WITH NO CHILDREN UNDER THE AGE OF 18, = 0, OTHERWISE . | 0.20 | 0.40 | 16 | 0.21 | 0.41 | 18 |
| FAM2 | = 1, MARRIED WITH CHILDREN UNDER THE AGE OF 18, = 0, OTHERWISE . | 0.68 | 0.47 | 16 | 0.63 | 0.48 | 18 |
| GRAD1 | PLACE OF GRADUATION : = 1, GRADUATE OF THE UNIVERSITY OF SASKATCHEWAN(OWING ON A BURSARY), = 0, OTHERWISE . | 0.02 | 0.15 | - | 0.02 | 0.13 | - |
| GRAD2 | = 1, GRADUATE OF A CANADIAN MEDICAL SCHOOL OUTSIDE SASKATCHEWAN, = 0, OTHERWISE . | 0.17 | 0.38 | - | 0.16 | 0.37 | - |
| GRAD3 | = 1, GRADUATE OF A MEDICAL SCHOOL OUTSIDE CANADA, = 0, OTHERWISE . | 0.62 | 0.49 | - | 0.64 | 0.48 | - |
| STAY1 | LENGTH OF TIME IN CURRENT LOCATION : = 1, IN TOWN LESS THAN 1 YEAR, = 0, OTHERWISE . | 0.12 | 0.33 | - | 0.14 | 0.35 | - |
| STAY2 | = 1, IN TOWN FROM 1 TO 2 YEARS, = 0, OTHERWISE . | [illegible] | 0.36 | - | 0.09 | 0.29 | - |

CONTINUED NEXT PAGE ...

TABLE IV.3 CONTINUED

| VARIABLE LABEL | DESCRIPTION | 1978 SAMPLE MEAN | 1978 SAMPLE S.D. | 1978 SAMPLE MISSING | 1979 SAMPLE MEAN | 1979 SAMPLE S.D. | 1979 SAMPLE MISSING |
|---|---|---|---|---|---|---|---|
| PRAC | TYPE OF PRACTICE: = 1, IN AN ASSOCIATED PRACTICE, = 0, IN A SOLO PRACTICE . | 0.70 | 0.46 | - | 0.69 | 0.46 | - |
| GROWTH | RATE OF GROWTH OF THE TOWN IN WHICH THE PHYSICIAN IS LOCATED . | 2.32 | 2.41 | - | 2.03 | 2.38 | - |
| DIST | DISTANCE FROM TOWN TO THE NEAREST OF REGINA OR SASKATOON (IN KM.'S) . | 190.69 | 75.19 | - | 187.00 | 74.80 | - |
| RATIO | DISTRICT POPULATION (RURAL MUNICIPALITY) PER ACTIVE PHYSICIAN IN THE DISTRICT (IN 000'S) . | 1.12 | 0.51 | - | 1.18 | 0.57 | - |
| P-ELD | % OF DISTRICT POPULATION OVER 65 . | 14.36 | 3.49 | - | 14.61 | 3.87 | - |
| P-TOWN | % OF DISTRICT POPULATION IN THE SAME TOWN AS THE PHYSICIAN . | 55.04 | 21.47 | - | 54.39 | 21.19 | - |
| BED1 | LEVEL 6 (ACUTE CARE) HOSPITAL BEDS IN TOWN PER ACTIVE PHYSICIAN . | 9.66 | 3.94 | - | 9.88 | 4.06 | - |
| BED2 | LEVEL 1 TO 3 (SUPERVISORY, PERSONAL, & BASIC NURSING CARE) HOSPITAL BEDS IN TOWN PER ACTIVE PHYSICIAN . | 11.47 | 9.72 | - | 11.76 | 9.82 | - |

observable. All that is known is whether a physician did, or did not, move and not the true probability of relocation. Using maximum likelihood estimation, however, estimates for the model parameters can be obtained. To illustrate, define $p^i$ as the probability of relocation for the $i^{th}$ sampled physician, so that

$$p^i = \Pr\{y^i = 1 | x^i\}$$
$$= \frac{\exp\{x^i \beta'\}}{1 + \exp\{x^i \beta'\}}$$

where

$y^i = 1$ for movers

$= 0$ for stayers,

$x^i$ = the 1 by 18 vector of measurements for the independent variables for physician i, and

$\beta$ = the 1 by 18 vector of model parameters.

If each individual's decision with respect to migration is independent of the decisions of other individuals, then the probability of observing a given sample of size "n" is

$$L(\beta; x^1, x^2, \ldots x^n) = \prod_i^n \{y^i p^i + (1 - y^i)(1 - p^i)\}$$

where L denotes the likelihood. The maximum likelihood estimates are then given by that value of $\beta$ which maximizes L. (A more detailed description of the estimation procedure is provided in appendix D).

One of the problems with the migration model, as it has been presented thus far, is that it implicitly assumes that physicians of all ages are making similar kinds of migration decisions. However, the decisions of older physicians are more likely to be associated with retirement than with practice opportunities in other locations. Similarly, many of the younger physicians will be headed for residencies in the various specialties. Both of these groups will react differently than physicians deciding between private practices in alternative locations.

As a result of these considerations, the model was fitted twice to the 1978 sample. In the first case, physicians of all ages were included. In the second case, physicians under age 30 and over age 60 were excluded. A priori, it was expected that the smaller sample would provide a better fit to the data.

Summary

This chapter has described the data that will be analyzed in subsequent chapters. The use of this data in the estimation of the migration model was also discussed.

## FOOTNOTES TO CHAPTER IV

[1]There were two factors which determined the selection of the 10,000 population mark as the cutoff for the study.

Firstly, the chosen cutoff was the one used by S.M.C.I.C. in its various statistical reports. Choosing the same level facilitated sample selection and data comparisons.

Secondly, there was a clear distinction in the availability of specialists between cities with populations over 10,000 and other areas in the province. No location outside of these major centers had more than one active specialist in 1980. In comparison, the smallest of the major centers, North Battleford, had seven active specialists in the same year (S.M.C.I.C., Annual Report 1980). Therefore, areas included in the study were distinguished by the fact that the vast majority of medical services were provided by general practitioners.

[2]These areas were excluded for the following reasons:

a) Swift Current Health Region: Located in the south-west corner of the province, the S.C.H.R. has operated a comprehensive medicare plan since 1948. Still largely independent of S.M.C.I.C., the primary source of data, sufficient information was not available to include S.C.H.R. physicians in the study.

b) Lloydminster: Located on the Saskatchewan-Alberta border, physicians in this city regularly register for payment under both S.M.C.I.C. and the Alberta Health Care Insurance Plan. In addition, they are often registered as beneficiaries under the Alberta medicare plan. Sufficient information, therefore, was not available to include these physicians in the study.

c) Uranium City: Located in the north-west corner of the province, the highway into this town is only open during the winter months. Because of their extreme isolation, it was decided to exclude these physicians from the study.

[3]The chosen cutoff was the one used by S.M.C.I.C. in its various statistical reports. Choosing the same level facilitated sample selection and data comparisons.

[4]The study concentrated on the movement of physicians from rural areas. Where possible, attrition from other sources, such as death, was excluded.

[5]See footnote 4 to this chapter.

[6]The model used in the study related the probability of a physician moving to a number of variables. The procedure used to estimate the

model assumed that the decision of one physician to move had no effect on the decisions of other physicians. This independence was violated in the case of husband and wife practices so that one partner had to be excluded.

[7] This problem was not of the magnitude expected. Only one physician, in the 1978 sample, moved less than 25 km. (See table IV.2).

[8] This problem did not show up for any of the sampled physicians. (See table IV.2).

# CHAPTER V

## RESULTS

This chapter presents estimates and tests of the parameters of the logistic model. In general, maximum likelihood estimation was employed and testing was carried out using t- statistics and likelihood ratios. These procedures are not discussed in the chapter, though a brief outline of their application to the logistic model is provided in appendix D.

### Comparison of Mean Values, 1978

In table V.1, the mean values for all the independent variables are compared for movers and stayers. Though these do not represent valid tests of the hypotheses stated in chapter III,[1] they are of some interest in their own right. For one, policy recommendations in the health manpower field are, more often than not, based on univariate statistics. In addition, the data used in the study has not been generally available, so that some simple summary statistics may be of interest.

Only three of the differences in mean values were significant. In general, movers tended to be younger, were more likely to be newly established, and were practicing in areas with low population - physician ratios.

These results are not very surprising in themselves. What is surprising are the magnitudes of two of the differences. First, newly established physicians, as measured by the variable STAY1, made up a much larger proportion of movers (34%) than stayers (8%). Second, the average values of RATIO for movers and stayers were, respectively, .94

TABLE V.1 : COMPARISON OF MEAN VALUES FOR MOVERS AND STAYERS, 1978

| VARIABLE | MEAN & (STD DEV): STAYERS | MEAN & (STD DEV): MOVERS | VALUE OF T-STATISTIC (D.F.) | REJECT HO : MEANS ARE EQUAL ? |
|---|---|---|---|---|
| AGE | 44.17 | 36.45 | 4.126 | YES |
| | (11.07) | ( 7.50) | (246) | |
| SEX | .10 | .16 | -1.159 | NO |
| | ( 0.29) | ( 0.37) | (246) | |
| FAM1 | .21 | .11 | 1.352 | NO |
| | ( 0.41) | ( 0.32) | (230) | |
| FAM2 | .69 | .63 | 0.659 | NO |
| | ( 0.47) | ( 0.49) | (230) | |
| GRAD1 | .02 | .05 | -1.239 | NO |
| | ( 0.14) | ( 0.23) | (246) | |
| GRAD2 | .19 | .11 | 1.204 | NO |
| | ( 0.39) | ( 0.31) | (246) | |
| GRAD3 | .60 | .71 | -1.236 | NO |
| | ( 0.49) | ( 0.46) | (246) | |
| STAY1 | .08 | .34 | -4.725 | YES |
| | ( 0.27) | ( 0.48) | (246) | |
| STAY2 | .14 | .18 | -0.656 | NO |
| | ( 0.35) | ( 0.39) | (246) | |
| PRAC | .70 | .71 | -0.188 | NO |
| | ( 0.46) | ( 0.46) | (246) | |
| GROWTH | 2.37 | 2.01 | 0.862 | NO |
| | ( 2.42) | ( 2.37) | (246) | |
| DIST | 190.58 | 191.32 | -0.056 | NO |
| | (76.70) | (67.17) | (246) | |
| RATIO | 1.15 | 0.94 | 2.453 | YES |
| | ( 0.53) | ( 0.32) | (246) | |
| P-ELD | 14.27 | 14.87 | -0.972 | NO |
| | ( 3.57) | ( 3.00) | (246) | |
| P-TOWN | 54.85 | 56.06 | -0.317 | NO |
| | (21.41) | (22.06) | (246) | |
| BED1 | 9.76 | 9.08 | 0.987 | NO |
| | ( 3.96) | ( 3.80) | (246) | |
| BED2 | 11.93 | 8.89 | 1.783 | NO |
| | ( 9.72) | ( 9.41) | (246) | |

NOTE : TESTING WAS CARRIED OUT AT THE 5.0 PERCENT LEVEL OF SIGNIFICANCE WITH THE VARIANCES IN THE INDEPENDENT VARIABLES BEING ASSUMED EQUAL FOR MOVERS AND STAYERS .

and 1.15, a difference of 22 percent.

Of the remaining variables it is difficult to say too much, none of the differences being significant. In some cases, the relative positions of the mover and stayer averages were contrary to the hypotheses stated in chapter III (eg. SEX and GRAD2). Until the other variables have been controlled for, however, no importance can be attached to these comparisons. In fact, this holds for all comparisons regardless of their statistical significance.

Parameter Estimates, 1978

Parameter estimates for the migration model, fitted for all sampled physicians,[2] are presented in table V.2. The value of the log likelihood is -75.115, which is highly significant (5.0 percent level) when compared to a value of -98.415 arising from a simple alternative model. This alternative model assumes that the probability of relocation was a constant for all physicians, equal to the proportion of movers in the sample.[3]

Coefficients for three of the variables, AGE, FAM2, and GRAD2, tested as being significantly different from zero (5.0 percent level) and were of the expected sign.[4] All other things being equal, the probability of relocation decreased with age and physicians with families were less likely to migrate than single physicians. Similarly, Saskatchewan graduates were not as mobile as other Canadian graduates.

The coefficient of GRAD3 was also significant. The sign (positive) indicates that foreign graduates were more mobile than Saskatchewan graduates, though this was not hypothesized *a priori*. What was hypothesized were the relative positions of foreign and [illegible] Canadian graduates. The coefficient of GRAD3 was less than that [illegible] GRAD2, as

TABLE V.2 : PARAMETER ESTIMATES FOR THE LOGISTIC PROBALITY MODEL OF PHYSICIAN MOBILITY, 1978

FOR ALL ACTIVE GENERAL PRACTIONERS

| VARIABLE | ESTIMATE (STD ERR) | VALUE OF T-STATISTIC | REJECT HO : PARAMETER = 0 ? | WAS INITIAL HYPOTHESIS CORRECT ? |
|---|---|---|---|---|
| CONSTANT | 3.739 (2.456) | 1.522 | NO | |
| AGE | -0.129 (0.035) | -3.723 | YES | YES |
| SEX | -0.013 (0.757) | -0.018 | NO | YES |
| FAM1 | -1.491 (0.827) | -1.804 | NO | YES |
| FAM2 | -1.486 (0.655) | -2.270 | YES | YES |
| GRAD1 | 0.578 (1.300) | 0.445 | NO | NO |
| GRAD2 | 2.252 (1.038) | 2.171 | YES | YES |
| GRAD3 | 1.475 (0.733) | 2.012 | YES | N/A |
| STAY1 | 0.594 (0.608) | 0.977 | NO | YES |
| STAY2 | -0.557 (0.678) | -0.821 | NO | NO |
| PRAC | 0.714 (0.572) | 1.248 | NO | NO |
| GROWTH | -0.017 (0.116) | -0.150 | NO | YES |
| DIST | -0.002 (0.003) | -0.523 | NO | NO |
| RATIO | -1.259 (0.851) | -1.480 | NO | YES |
| P-ELD | 0.076 (0.077) | 0.992 | NO | NO |
| P-TOWN | 0.000 (0.012) | 0.021 | NO | NO |
| BED1 | 0.018 (0.072) | 0.245 | NO | NO |
| BED2 | -0.053 (0.036) | -1.477 | NO | YES |

NOTES :
1) PARAMETER TESTS WERE CARRIED OUT AT THE 5.0 % LEVEL .
2) SAMPLE SIZE : STAYERS = 197, MOVERS = 35 .
3) VALUE OF LOG LIKELIHOOD : A) WITH CONSTANT ONLY = -98.415
B) FULL MODEL = -75.115
4) -2(CHANGE IN LOG LIKLEHOOD) = 46.600 (SIGNIFICANT AT THE 5.0 PER CENT LEVEL, WITH 17 DEGREES OF FREEDOM).

was expected, but the difference was not significant.

The coefficients for six of the variables were of the expected sign but insignificant. These were the variables SEX, FAM1, GROWTH, BED2, RATIO, and STAY1. One problem with these results may be a high degree of multicollinearity. To assess its impact, each independent variable was regressed against the remaining independent variables. The coefficients of determination, $R^2$'s, were generally quite low, though it must be remembered that several of the variates are simple dichotomies.

| $R^2$ | Variables |
|---|---|
| .6 to .699 | FAM2 |
| .5 to .599 | AGE, FAM1, GRAD2, GRAD3 |
| .4 to .499 | |
| .3 to .399 | STAY2, P-ELD, P-TOWN |
| .2 to .299 | GRAD1, STAY1, PRAC, DIST, GROWTH, RATIO, BED2 |
| .1 to .199 | SEX, BED1 |

A second measure of the degree of multicollinearity was obtained by calculating the eigenvalues for the correlation matrix of the independent variables.[5] The first principal component accounted for 14.3 percent of the total variation (eigenvalue of 2.4) while the last component accounted for 1.2 percent (eigenvalue of .2).[6] While these results suggest some degree of multicollinearity, the eigenvalues were not all equal to 1, the problem does not appear to be a severe one.

To the extent that multicollinearity was present in the sample, the parameter tests are not as powerful as one would hope. This does not mean that the coefficients would have tested as signficant if there had been no multicollinearity. It simply implies that the tests may be poor in discriminating between true and false null hypotheses.

The coefficients of the remaining seven variables were all insignificant and of the wrong sign. Four of these must be considered as anomalies which arose from either relationsips between the variables or sampling error. It is difficult, for example, to come up with a logical explanation for physicians in a town for one to two years (STAY2) being more stable than physicians in the town for over two years. Similar comments can be made regarding the variables BED1, P-TOWN, and GRAD1.[7]

The wrong signs for PRAC, DIST, and P-ELD may be the result of mis-specified hypotheses. These are discussed separately below.

1) There are two reasons why PRAC may have a positive coefficient. First, the opportunity to join a group practice has been found to be an important factor in the location decisions of physicians.[8] Therefore, compared to solo practitioners, physicians in associated practices may be able to recoup a larger percentage of their investment in the area when it comes time to relocate. Second, in a study conducted by the College of Medicine, University of Saskatchewan,[9] it was found that difficulties often arose between partners of widely varying ages. The variable PRAC may be picking up some of this effect.

It should also be noted that information on the type of practice partnership was not available and that this may have led to a distortion of the results. For example, younger physicians without full partnerships may not have been able to realize the full benefits of the economic potential of the area in which they were located. Hence the variable PRAC may have been measuring different things for different physicians.

2) Physicians in the urban centers of Regina and Saskatoon draw in a considerable number of patients from the surrounding rural areas. This could account for the negative coefficient of the variable DIST.[10]

3) Physicians have often been cited for their negative attitudes towards elderly patients.[11] Therefore, a large percentage of persons

over the age of 65 may insure a healthy demand for medical services, but it may not result in "rewarding" practices.

As was mentioned in chapter IV, a second fit to the logistic model was obtained using only those physicians between the ages of 30 and 60. The parameter estimates for this data set are presented in table V.3. The value of log likelihood was -64.102, which is highly significant when compared to a value of -81.670 obtained for the constant probability model.

Parameter estimates from the two data sets are roughly comparable. Thirteen of the coefficients are of the same sign and test identically as to their significance from zero. Two coefficents, for GRAD2 and GRAD3, are of the same sign for both samples but test as insignificant in one case (ages 30 to 60 sample), but not the other. Finally, the coefficients of BED1 and P-TOWN were of the correct sign (negative) in the ages 30 to 60 sample and of the wrong sign in the all ages sample.

## The Demand Variables

The variables RATIO, P-ELD, and P-TOWN are of particular interest given their hypothesized relationships to the demand for a physician's services and, from that, to the probability of relocation. Because of their importance, it was decided to do some additional tests involving these variables. The basic question was, how well does the model perform without the demand variables? In answer, four likelihood ratio tests were carried out. These compared the specified model with models excluding

1) RATIO,
2) P-TOWN,
3) P-ELD, and
4) RATIO, P-TOWN, and P-ELD.

TABLE V.3 : PARAMETER ESTIMATES FOR THE LOGISTIC PROBALITY MODEL OF PHYSICIAN MOBILITY, 1978 FOR ALL ACTIVE GENERAL PRACTIONERS BETWEEN THE AGES OF 30 AND 60

| VARIABLE | ESTIMATE (STD ERR) | VALUE OF T-STATISTIC | REJECT H0 : PARAMETER = 0 ? | WAS INITIAL HYPOTHESIS CORRECT ? |
|---|---|---|---|---|
| CONSTANT | 3.159 (2.784) | 1.135 | NO | |
| AGE | -0.107 (0.040) | -2.686 | YES | YES |
| SEX | -0.140 (0.875) | -.0160 | NO | YES |
| FAM1 | -1.626 (0.984) | -1.652 | NO | YES |
| FAM2 | -1.503 (0.735) | -2.045 | YES | YES |
| GRAD1 | 1.142 (1.957) | 0.584 | NO | NO |
| GRAD2 | 2.128 (1.087) | 1.958 | NO | YES |
| GRAD3 | 1.297 (0.853) | 1.520 | NO | N/A |
| STAY1 | 0.725 (0.695) | 1.042 | NO | YES |
| STAY2 | -0.580 (0.819) | -0.708 | NO | NO |
| PRAC | 0.880 (0.632) | 1.392 | NO | NO |
| GROWTH | -0.076 (0.131) | -0.578 | NO | YES |
| DIST | -0.004 (0.004) | -0.983 | NO | NO |
| RATIO | -0.934 (0.825) | -1.132 | NO | YES |
| P-ELD | 0.106 (0.085) | 1.244 | NO | NO |
| P-TOWN | -0.006 (0.013) | -0.427 | NO | YES |
| BED1 | -0.006 (0.075) | -0.078 | NO | YES |
| BED2 | -0.054 (0.037) | -1.457 | NO | YES |

NOTES : 1) PARAMETER TESTS WERE CARRIED OUT AT THE 5.0 % LEVEL .
2) SAMPLE SIZE : STAYERS = 155, MOVERS = 25 .
3) VALUE OF LOG LIKELIHOOD : A) WITH CONSTANT ONLY = -81.670
B) FULL MODEL = -64.102
4) -2(CHANGE IN LOG LIKLEHOOD) = 35.136 (SIGNIFICANT AT THE 5.0 PER CENT LEVEL, WITH 17 DEGREES OF FREEDOM).

Details of the tests are provided in table V.4. In summary, the results confirm those found when simple t-ratios were employed. The demand variables, either individually or in combination,[12] do not add significantly to the understanding of physician migration decisions.

A second consideration involving the demand variables was the measurement of RATIO. This was defined as the number of persons in the rural municipality divided by the number of active physicians. There may be a problem in so far as not all active physicians would have been in full time practice.

In response to this problem, a second measure of RATIO was calculated. This was defined as the population of the rural municipality divided by a rough measure of the number of full time equivalent physicians.[13] The migration model was then refitted using this new definition of RATIO.

The use of full time equivalents had very little effect on the parameter estimates. For the ages 30 to 60 sample, there were no changes in the signs of any of the coefficients. In addition, there were no reversals in the tests of significance. The fit for the all ages sample gave similar results, though in that case the signs of two of the coefficients (for BED1 and P-TOWN) did switch from positive to negative.

Goodness of Fit

In assessing how well the model fit the 1978 sample, three procedures were employed. The results are presented in table V.5 and discussed separately below.

1) Physicians were placed into a decile of risk according to the estimated probability of relocation. For example, the first decile represented physicians with an estimated probability equal to or less

TABLE V.4 : ADDITIONAL TESTS OF THE VARIABLES RATIO, P-ELD, & P-TOWN

| | ALL PHYSICIANS | PHYSICIANS 30 TO 60 |
|---|---|---|
| 1.A) VALUE OF LOG LIKELIHOOD : | | |
| - EXCLUDE RATIO, P-ELD, P-TOWN | -78.082 | -66.399 |
| - FULL MODEL | -75.115 | -64.102 |
| B) -2(CHANGE IN LOG LIKELIHOOD) | 5.934 | 4.594 |
| C) DEGREES OF FREEDOM | 3 | 3 |
| D) CRITICAL VALUE | 7.815 | 7.815 |
| E) SIGNIFICANT CHANGE ? | NO | NO |
| 2.A) VALUE OF LOG LIKELIHOOD : | | |
| - EXCLUDE RATIO | -76.397 | -64.857 |
| - FULL MODEL | -75.115 | -64.102 |
| B) -2(CHANGE IN LOG LIKELIHOOD) | 2.564 | 1.510 |
| C) DEGREES OF FREEDOM | 1 | 1 |
| D) CRITICAL VALUE | 3.841 | 3.841 |
| E) SIGNIFICANT CHANGE ? | NO | NO |
| 3.A) VALUE OF LOG LIKELIHOOD : | | |
| - EXCLUDE P-ELD | -75.606 | -64.885 |
| - FULL MODEL | -75.115 | -64.102 |
| B) -2(CHANGE IN LOG LIKELIHOOD) | .982 | 1.566 |
| C) DEGREES OF FREEDOM | 1 | 1 |
| D) CRITICAL VALUE | 3.841 | 3.841 |
| E) SIGNIFICANT CHANGE ? | NO | NO |
| 4.A) VALUE OF LOG LIKELIHOOD : | | |
| - EXCLUDE P-TOWN | -75.116 | -64.192 |
| - FULL MODEL | -75.115 | -64.102 |
| B) -2(CHANGE IN LOG LIKELIHOOD) | .002 | .180 |
| C) DEGREES OF FREEDOM | 1 | 1 |
| D) CRITICAL VALUE | 3.841 | 3.841 |
| E) SIGNIFICANT CHANGE ? | NO | NO |

TABLE V.5 : GOODNESS OF FIT, 1978

1. COMPARISONS OF ESTIMATED DECILES OF RISK WITH RELOCATION RATES

| ALL PHYSICIANS | | | | PHYSICIANS 30 TO 60 | | | |
|---|---|---|---|---|---|---|---|
| DECILE | NUMBER OF PHYSICIANS | MOVERS | RATE OF RELOCATION | DECILE | NUMBER OF PHYSICIANS | MOVERS | RATE OF RELOCATION |
| 1 | 125 | 6 | 4.80 % | 1 | 106 | 6 | 5.66 % |
| 2 | 46 | 4 | 8.70 % | 2 | 38 | 2 | 5.26 % |
| 3 | 25 | 7 | 28.00 % | 3 | 22 | 7 | 31.82 % |
| 4 | 13 | 4 | 30.77 % | 4 | 10 | 5 | 50.00 % |
| 5 | 8 | 5 | 62.50 % | 5 | 6 | 3 | 50.00 % |
| 6 | 7 | 4 | 57.14 % | 6 | 3 | 1 | 33.33 % |
| 7 | 4 | 2 | 50.00 % | 7 | 6 | 3 | 50.00 % |
| 8 | 4 | 3 | 75.00 % | 8 | 2 | 2 | 100.00 % |
| 9 | - | - | - | 9 | - | - | - |
| 10 | - | - | - | 10 | - | - | - |

2. SUCCESSES, SUCCESS RATES, AND SUCCESS INDICES

| ALL PHYSICIANS | | PHYSICIANS 30 TO 60 | |
|---|---|---|---|
| SUCCESSES | | SUCCESSES | |
| - MOVERS | 9 OF 35 | - MOVERS | 6 OF 29 |
| - STAYERS | 191 OF 197 | - STAYERS | 159 OF 164 |
| TOTAL | 200 OF 232 | TOTAL | 165 OF 193 |
| SUCCESS RATES | | SUCCESS RATES | |
| - MOVERS | 25.71 % | - MOVERS | 20.69 % |
| - STAYERS | 96.95 % | - STAYERS | 96.95 % |
| TOTAL | 86.21 % | | 85.49 % |
| SUCCESS INDEX | 46.17 | SUCCESS INDEX | 43.19 |

than .1, the second represented probabilities greater than .1 but equal to or less than .2, and so on.

In general, the proportion of movers tended to increase with the decile of risk. The model provided a good fit to both data sets.

2) A second procedure assesses the model according to classification results. Physicians with an estimated probability of relocation greater than .5 were classified as movers, all others being classified as stayers. The classification results are then compared with the actual distribution of movers and stayers.

Using the all ages data as an example, 97.0 percent of stayers and 25.7 percent of movers were correctly classified, with an overall success rate of 86.2 percent. Similar results were found for the ages 30 to 60 data, the overall success rate being 85.5 percent.

3) The percentages of movers and stayers for the entire sample were 15.09 and 84.91 respectively. A simple alternative to the classification procedure discussed above would have been to randomly assign physicians as movers or stayers in these proportions. The expected number of correct classifications, E, would then be

$$E = (35)(.1509) + (197)(.8491)$$
$$= 172.55.$$

This number can then be used in the construction of an index[14] which compares the performance of the specified model against the constant probability model. This is given by

$$\text{Index} = \left[\frac{C - E}{N - E}\right] 100$$
$$= \left[\frac{200 - 172.55}{232 - 172.55}\right] 100$$
$$= 46.17.$$

where C is the number of correct classifications for the specified model and N is the total sample size. The index ranges from zero (no improvement) to 100.

The index value of 46.17 indicates that the specified model represents a considerable improvement over a pure chance mechanism. A similar value of 43.19 was found for the sample containing only those physicians between the ages of 30 and 60.

In general, the model provided a good fit to the data. In chapter IV it was indicated that the model would provide a better fit if the sample was restricted to physicians aged 30 to 60. This was not borne out. In terms of goodness of fit, the model performed equally as well for the sample containing physicians of all ages.

Prediction, 1979

Using the 1978 parameter estimates, the migration decisions of physicians contained in the 1979 sample were investigated. The procedures employed (see table V.6) were identical to those described in the preceding section.

The incidence of migration did tend to increase with the decile of risk. For both data sets, however, the results do tend to break down for the higher estimated probabilities of relocation. This occurs at the 7th and 6th deciles for the all ages and ages 30 to 60 data sets respectively.

The classification results[15] also suggest that the model has some predictive capability. For the entire sample, the success rate was 79.74 percent and the success index was 24.33. The comparable figures for the ages 30 to 60 sample were 82.26 percent and 30.58.

As was discussed in chapter IV, information on family structure was missing for 18 physicians in the 1979 sample. All of these physicians

TABLE V.6 : PREDICTION RESULTS, 1979

1. COMPARISONS OF ESTIMATED DECILES OF RISK WITH RELOCATION RATES

| ALL PHYSICIANS | | | | PHYSICIANS 30 TO 60 | | | |
|---|---|---|---|---|---|---|---|
| DECILE | ALL PHYSICIANS | MOVERS | RATE OF RELOCATION | DECILE | ALL PHYSICIANS | MOVERS | RATE OF RELOCATION |
| 1 | 131 | 14 | 10.69 % | 1 | 104 | 11 | 10.58 % |
| 2 | 42 | 9 | 21.43 % | 2 | 49 | 11 | 22.45 % |
| 3 | 22 | 5 | 22.73 % | 3 | 14 | 3 | 21.43 % |
| 4 | 9 | 2 | 22.22 % | 4 | 7 | 0 | 0.00 % |
| 5 | 5 | 3 | 60.00 % | 5 | 5 | 2 | 40.00 % |
| 6 | 7 | 3 | 42.86 % | 6 | 4 | 0 | 0.00 % |
| 7 | 3 | 0 | 0.00 % | 7 | 1 | 1 | 100.00 % |
| 8 | 2 | 0 | 0.00 % | 8 | 2 | 0 | 0.00 % |
| 9 | 3 | 1 | 33.33 % | 9 | - | - | - |
| 10 | 3 | 1 | 33.33 % | 10 | - | - | - |

2. SUCCESSES, SUCCESS RATES, AND SUCCESS INDICES

| ALL PHYSICIANS | | PHYSICIANS 30 TO 60 | |
|---|---|---|---|
| SUCCESSES | | SUCCESSES | |
| - MOVERS | 5 OF 38 | - MOVERS | 1 OF 28 |
| - STAYERS | 176 OF 189 | - STAYERS | 152 OF 158 |
| TOTAL | 181 OF 227 | TOTAL | 153 OF 186 |
| SUCCESS RATES | | SUCCESS RATES | |
| - MOVERS | 13.16 % | - MOVERS | 3.57 % |
| - STAYERS | 93.12 % | - STAYERS | 96.20 % |
| TOTAL | 79.74 % | | 82.26 % |
| SUCCESS INDEX | 24.33 | SUCCESS INDEX | 30.58 |

were excluded from the analysis presented in table V.6. As shown below, however, the inclusion of these physicians[16] had very little impact on the classification results.

| | All Ages | Ages 30 - 60 |
|---|---|---|
| Successes | 195 of 245 | 166 of 201 |
| Success Rate | 79.59% | 82.59% |
| Success Index | 22.96 | 30.68 |

## Summary

This chapter has presented estimates and tests of the parameters of the migration model. The implications of these results will be discussed in the next chapter.

## FOOTNOTES TO CHAPTER V

[1] All hypotheses were stated *ceteris paribus*. For example, to state that females move less frequently than males is not the same as stating that, all other things being equal, females are less mobile than males.

[2] Except those with missing values for the variables FAM1 and FAM2, of which there were 16 in the 1978 sample. Refer to chapter IV and appendix C.

[3] Of course, there is an infinite number of other models that could have been employed. Therefore, it cannot be said that the specified model is the true model, only that the selected variables appear to pick up some of the variation in the probability of relocation.

[4] When tested at the 1% level only AGE remains as a significant variable. When tested at the 10% level, FAM1 is added to the list of significant variables.

[5] S. Daultrey, *Principal Component Analysis* (Norwich: Geo Abstracts, n.d.) and J. Johnston, *Econometric Methods* (New York: McGraw Hill, 1972), pp. 322-34.

[6] The eigenvalues, and their percentage contribution to the total variation, were as follows: 2.43 (14.3%); 2.27 (13.4%); 1.85 (10.9%); 1.55 (9.1%); 1.38 (8.1%); 1.19 (7.0%); .94 (5.5%); .89 (5.2%); .80 (4.7%); .74 (4.3%); .66 (3.9%); .60 (3.5%); .46 (2.7%); .45 (2.6%); .35 (2.1%); .24 (1.4%); .20 (1.2%).

[7] With respect to GRAD1, it should also be noted that the number of graduates still owing on a medical school bursary was very small, only four in the 1978 sample.

[8] J. K. Cooper, K. Heald, and S. Coleman, "Rural or Urban Practice: Factors Influencing the Location Decisions of Primary Care Physicians," *Inquiry* 12 (1975): 18-25 and McFarland, "Toward an Explanation of the Geographical Location of Physicians in the United States."

[9] Sarich, *Medical Practice in Saskatchewan*.

[10] If this interpretation is correct, then the variable DIST has not been entered into the model correctly. Rather, a dummy variable should have been employed which, for example, would be set equal to 1 if the distance to the nearest of Regina or Saskatoon was less than 70 km. This specification recognizes that the "drawing in" effect of the large urban centers eventually drops off to zero.

[11] Gross and Schwenger, Health Care Costs for the Elderly in Ontario: 1976-2026, p. 81.

[12] It should be noted that the combination of any two of the variables RATIO, P-ELD, and P-TOWN will also not add significantly to the model. This can be inferred from the information given in table V.4.

[13] The number of full time equivalent physicians was defined as the total, fourth quarter, S.M.C.I.C. payments to active physicians in the area divided by $18,125.

The full time payment figure was derived after an examination of the payment distribution to S.M.C.I.C. physicians (S.M.C.I.C., Annual Report 1978, pp. 46-7). It should be noted that while the choice of the full time figure will influence the size of the estimated coefficient for the variable RATIO, it will have no effect on tests of significance involving the parameter.

[14] W. R. Klecka, Discriminant Analysis (Beverly Hills: Sage Publications, 1980), pp. 50-1.

[15] It was assumed that cost of misclassification were equal for movers and stayers. It should also be noted that, in the calculation of the success index, the proportions of movers and stayers in the 1978 sample were employed. Therefore, the success index compares the performance of the migration model fitted to the 1978 sample with a model that assumes that the probability of relocation in 1979 was a constant for all physicians equal to the proportion of movers in the 1978 sample.

[16] This requires that the missing values of FAM1 and FAM2 be estimated. Refer to appendix C.

CHAPTER VI

# CONCLUSIONS

With regards to the future geographic distribution of Saskatchewan physicians, two of the government's policies are of particular importance. These policies are evaluated below in terms of the results obtained for the migration model. It should be noted at the outset, however, that any suggestions must be regarded as tentative. The results of the study, as reported in chapter V, were not particularly strong and do not inspire a great deal of confidence in the model.

## Licensing of Foreign Graduates

It was found that foreign medical graduates tended to be more mobile than graduates of the University of Saskatchewan and as mobile as graduates from universities in other Canadian provinces. At the same time, however, other data suggests that foreign graduates are making up an increasing proportion of rural physicians. In 1973, for example, foreign, Saskatchewan, and other Canadian graduates made up, respectively, 56.9, 19.4, and 23.7 percent of rural general practitioners. By the end of 1978, these numbers had changed to 63.7, 18.3, and 18.0 percent.[1]

The two observations stated above are not inconsistent, as long as foreign graduates make up a large enough proportion of the physicians entering rural areas. In that case, even if foreign graduates do relocate at higher rates, the net effect of their migrations may still lead to an increasing percentage of rural physicians being foreign graduates.

This interpretation is supported when the location decisions of physician registering with S.M.C.I.C. in 1976 are considered. In that year, 43 registrants located in rural areas of which 88.4 percent were foreign graduates and 11.6 percent were Canadian graduates. By mid-1980, the number of 1976 registrants in rural areas had dropped to 21 and the percentages of foreign and Canadian graduates were, respectively, 81.0 and 19.0 percent.[2] Clearly, this data suggests that foreign graduates have left rural areas at higher rates and yet, at the same time, have played an increasingly important role in the supply of rural physicians.

This situation does not bode well for future trends in the geographic distribution of physician manpower. The increased restrictions on foreign graduates, discussed in chapter II, can be expected to have two effects.

Firstly, the urban concentration of physicians can be expected to continue and at a higher rate than has been experienced in the past. Of the 31 Canadian graduates registering with S.M.C.I.C. in 1976, 83.9 percent located in an urban area in that year. The corresponding rate for the 72 foreign graduate registrants was only 47.2 percent.[3]

Secondly, rural areas may actually begin losing physician manpower. The increasing number of rural physicians over the past decade has been the result of a high number of physicians leaving rural areas accompanied by a slightly higher number of new entrants. Having cutoff the major source of new entrants -- i.e., foreign graduates -- the stock of rural physician manpower may begin to drop.

Whether or not the above predictions are borne out, and to what extent, will depend on a number of factors. First, Canadian graduates will have to continue favouring urban over rural areas. Second, policies aimed at attracting physicians will have to remain ineffective. Finally, the change in licensure policy will have to have a significant impact on the number of foreign graduates choosing to locate in the province. Whether or not this last factor will come into effect has yet to be fully evaluated, the change in licensure requirements only having been implemented in September of 1981.

Medical Practice Establishment Program

The migration model presented in the study has considerable potential for the evaluation of the Medical Practice Establishment Program. In brief, the program provides matching grants up to $5,000 per year, for three years, to assist communities in attracting Canadian trained physicians.[4] Various aspects of the program are discussed below.

1. Effect of Income

The underlying rationale for the program is that the relative unattractiveness of certain communities can be outweighed through payments to physicians. The general theoretical background to the migration model supports this assumption, though the evidence from the study was weak. With relation to the variable RATIO, the sign of the coefficient was positive, as expected, but insignificant. In other words, the evidence was not strong enough to reject the hypothesis, within the prescribed level of confidence, that RATIO had no effect on the probability of relocation.

2. Length of Stay

Obviously, the program will be most cost effective if physicians tend to stay in the community once the grants have run out. This can be expected to be the case if the establishment of a practice represents an investment to the physician which cannot be fully recaptured when the physician relocates.

Again, the evidence from the model only provided weak support for this assumption. The sign of STAY1 (in town for less than one year) was of the correct sign but insignificant. The sign of STAY2 (in town for one to two years) was of the wrong sign and insignificant.

3. Effect of Place of Graduation

Foreign graduates were found to be more mobile than Saskatchewan graduates and as mobile as other Canadian graduates, both results being statistically significant.[5] The question arises as to whether the program's discrimination in favour of Canadian trained physicians is justifiable. In terms of Saskatchewan graduates, it clearly is. These physicians are more stable than other place of graduation groups and, therefore, are more likely to stay in the community once the grants have stopped.

Discriminating in favour of other Canadian graduates is, however, not justifiable as their rates of relocation are similar to foreign graduates. Unless other benefits to having Canadian graduates are assumed,[6] this aspect of the program is difficult to defend.

4. Rates of Relocation

The results of the study can also be used to rank communities in order of the probability of losing a physician. This can be done by calculating values for the logistic equation using the variable values for each community and the set of sample mean values for those variables related to individual physicians. The resulting estimates will help to identify those communities least likely to be able to attract and/or retain a physician. This information should prove useful in the administration of any program which attempts to redistribute the stock of physicians.

In summary, the general approach taken in the study has potential for the evaluation of public policies. The application of the approach, however, was disappointing. The statistical results were weak, leading to a great deal of hedging in the policy analysis.

<u>Further Research</u>

If nothing else, it is hoped that the study will provide a spur to further research. The problems of physician distribution are great and, as suggested earlier, micro studies of physician migration may provide some answers. Several avenues for further study can be suggested.

For one, the choice of the independent variables should be re-evaluated. There are two approaches. First, the theoretical basis for variable selection can be examined. Second, variable selection techniques can be employed.

By way of illustration, a stepwise procedure was applied to the 1978 sample, the results being reported in tables VI.1 and VI.2.[7] The only variables entering in the model were AGE, STAY1, and RATIO. Though these results cannot be taken as confirmation of a subset of the research hypotheses, they do have some implications. In particular, future research should not ignore variables related to the demand for a physician's services. This is suggested by the sign and significance of the coefficient for RATIO.

Another avenue for research would be to expand upon the definition of the dependent variable. It would be interesting, for example, to compare physicians who stay in rural areas with those who a) retire,

TABLE VI.1 : STEPWISE SELECTION OF VARIABLES, 1978

FOR ALL ACTIVE GENERAL PRACTITIONERS

| VARIABLE | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|
| CONSTANT | -1.727 | 1.823 | 3.562 | 2.785 | 3.026 |
| | (-9.450) | ( 2.063) | ( 3.015) | ( 2.263) | ( 2.414) |
| AGE | | -0.089 | -0.092 | -0.077 | -0.079 |
| | | (-3.837) | (-3.850) | (-3.227) | (-3.260) |
| RATIO | | | -1.592 | -1.585 | -1.433 |
| | | | (-2.387) | (-2.318) | (-2.135) |
| STAY1 | | | | 1.159 | 1.126 |
| | | | | ( 2.375) | ( 1.982) |
| BED2 | | | | | -0.033 |
| | | | | | (-1.267) |
| LL : PREVIOUS MODEL | | -98.415 | -88.802 | -85.183 | -82.473 |
| : CURRENT MODEL | -98.415 | -88.802 | -85.183 | -82.473 | -81.636 |
| -2(CHANGE IN LL) | | 19.226 | 7.238 | 5.420 | 1.674 |
| SIGNIFICANT CHANGE IN LL ? (TESTING AT 5.0 % LEVEL) | | YES | YES | YES | NO |

NOTES : 1) FIGURES IN BRACKETS REPRESENT T-RATIOS FOR THE PARAMETER ESTIMATES.
2) 'LL' REFERS TO THE VALUE OF THE LOG LIKELIHOOD .
3) TESTING AT THE 5.0 PERCENT LEVEL, THE CRITICAL VALUE FOR THE CHI SQUARE DISTRIBUTION, WITH ONE DEGREE OF FREEDOM, IS 3.841 .
4) FOR A COMPLETE DESCRIPTION OF THE PROCEDURE, REFER TO APPENDIX D .

TABLE VI.2 : STEPWISE SELECTION OF VARIABLES, 1978

FOR ACTIVE GENERAL PRACTITIONERS BETWEEN THE AGES OF 30 AND 60

| VARIABLE | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|
| CONSTANT | -1.733 | 1.894 | 3.435 | 2.524 | 2.796 |
| | (-8.601) | (-1.639) | ( 2.470) | ( 1.728) | ( 1.874) |
| AGE | | -0.089 | -0.091 | -0.074 | -0.075 |
| | | (-3.050) | (-3.044) | (-2.438) | (-2.461) |
| RATIO | | | -1.457 | -1.381 | -1.238 |
| | | | (-2.123) | (-1.990) | (-1.836) |
| STAY1 | | | | 1.146 | 1.119 |
| | | | | ( 2.051) | ( 1.982) |
| BED2 | | | | | -0.036 |
| | | | | | (-1.342) |
| LL : PREVIOUS MODEL | | -81.670 | -76.273 | -73.370 | -71.362 |
| : CURRENT MODEL | -81.670 | -76.273 | -73.370 | -71.362 | -70.407 |
| -2(CHANGE IN LL) | | 10.794 | 8.298 | 4.016 | 1.910 |
| SIGNIFICANT CHANGE IN LL ? (TESTING AT 5.0 % LEVEL) | | YES | YES | YES | NO |

NOTES :
1) FIGURES IN BRACKETS REPRESENT T-RATIOS FOR THE PARAMETER ESTIMATES.
2) 'LL' REFERS TO THE VALUE OF THE LOG LIKELIHOOD .
3) TESTING AT THE 5.0 PERCENT LEVEL, THE CRITICAL VALUE FOR THE CHI SQUARE DISTRIBUTION, WITH ONE DEGREE OF FREEDOM, IS 3.841 .
4) FOR A COMPLETE DESCRIPTION OF THE PROCEDURE, REFER TO APPENDIX D .

b) go into residency programs, c) relocate to urban areas, and d) relocate to another rural area. Admittedly, however, this type of analysis may run into difficulties in terms of the sample sizes required for the various cells.[8]

Finally, improved information would be of some assistance. This includes data on licensure and on the types of economic relationships for physicians in associated practices. In addition, the definition of the market area for a physician's services, required for the measurement of the variable RATIO, could be usefully examined. Work on the location of patients with respect to the location of physicians has just begun at S.M.C.I.C., so that there may be some answers in the future.

## Summary

The study has been more effective in illustrating how micro studies of physician behaviour can be usefully applied to questions of public policy rather than coming up with any hard recommendations. Hopefully this will lead to further research, a few suggestions for which were presented.

## FOOTNOTES TO CHAPTER VI

[1]S.M.C.I.C., Annual Report, (various years).

[2]The data was obtained from unpublished S.M.C.I.C. files. Only general practitioners are included in the counts of new registrants.

[3]Refer to f.2 of this chapter.

[4]The program was described in greater detail in chap. II.

[5]This refers to the model fitted to the entire 1978 sample. Results for the ages 30 to 60 sample suggested that the coefficients for GRAD2 and GRAD3 were both insignificant.

[6]One assumption might be that Canadian trained physicians provide a higher quality of care. The evidence for this, however, is very weak. Refer, for example, to Evans, "Does Canada Have too Many Doctors?--Why Nobody Loves an Immigrant Physician."

[7]The procedure is described in appendix D.

[8]One way around this problem may be to extend the time frame for the study. For example, physicians moving within a five year period could be examined.

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# APPENDIX A

## DETAILED DESCRIPTIONS FOR THE INDEPENDENT VARIABLES

This appendix specifies the sources of information for the independent variables used in the study. In addition, the definitions of table III.1 have been expanded upon for some of the variables.

1. AGE

   Source: S.M.C.I.C., Physician Mobility File, (confidential file maintained by the Commission).

2. SEX

   Source: Ibid.

3. FAM1, FAM2

Families registered under the province's health care plans receive a unique registration number, with individual family members being identified with a beneficiary number. The file of these numbers, commonly referred to as reg-bens, is maintained by the Saskatchewan Hospital Services Plan (S.H.S.P.).

For administrative purposes, the reg-bens of all physicians are maintained on the S.M.C.I.C. Physician Register. It was a simple task, therefore, to supply S.H.S.P. with a list of these numbers along with a request for the following pieces of information.

a) The number of beneficiaries listed under the same registration as of December 31 of the sample year. This provided a count of family size.

b) The marital status indicator for the reg-ben number. (There are five possible values: 1 = single; 2 = married; 3 = separated; 6 = spouse not registered with S.H.S.P.; 7 = widow).

Using the above information, the values of FAM1 and FAM2 were determined according to the table given below.

| Marital Status | Number of Beneficiaries | Variable Value (Description) |
|---|---|---|
| 2 | 2 | FAM1 = 1; FAM2 = 0 (Married - No children) |
| 2 | $\geq 3$ | FAM1 = 0; FAM2 = 1 (Married - With children) |
| 1, 3, 6 or 7 | $\geq 1$ | FAM1 = 0; FAM2 = 0 (Single) |

It should be noted that individuals receive their own registration numbers upon reaching the age of eighteen. Therefore, the married with no children category should be interpreted as married with no children under the age of eighteen.

Source: Saskatchewan Hospital Services Plan, Master Registration File, (confidential file maintained by the Plan).

4. GRAD1, GRAD2, GRAD3

Values for these variables were determined according to the table given below.

| Variable Values | Interpretation |
|---|---|
| GRAD1 = 0; GRAD2 = 0, GRAD3 = 0 | Saskatchewan graduates not owing on a bursary. |
| GRAD1 = 1; GRAD2 = 0, GRAD3 = 0 | Saskatchewan graduates owing on two, or more, bursary units as of December 31 of the sample year. /Refer to chapter II for a description of the Medical Scholarship and Bursaries Act (1963)/. |
| GRAD1 = 0; GRAD2 = 1; GRAD3 = 0 | Graduates of Canadian medical schools outside Saskatchewan. |
| GRAD1 = 0; GRAD2 = 0; GRAD3 = 1 | Graduates of foreign medical schools. |

Sources: a) S.M.C.I.C., Physician Mobility File.

b) S.M.C.I.C., Bursary File, (confidential file maintained by the Commission).

5. STAY1, STAY2

The calculations of these variables were based on the length of time the physician had been continuously at his December 31 location. Absenses of less than 30 days were ignored unless this corresponded with the physician practicing in another location either outside or inside Saskatchewan.

Source: S.M.C.I.C., *Physician Mobility File*.

6. PRAC

Source: Ibid.

7. GROWTH

Denoting the population of the town in which the physician was located by POP(year), then for the 1978 sample,

$$\text{GROWTH} = \left[\left[\frac{\text{POP}(1978)}{\text{POP}(1973)}\right]^{1/5} - 1\right] \text{X } 100$$

and, for the 1979 sample,

$$\text{GROWTH} = \left[\left[\frac{\text{POP}(1979)}{\text{POP}(1973)}\right]^{1/6} - 1\right] \text{X } 100.$$

Source: Saskatchewan Hospital Services Plan, *Covered Population*, (Regina: Saskatchewan Health, various years).

8. DIST

Source: Saskatchewan Department of Highways, *Official Highways Map*, 1982.

9. RATIO

Using the 1978 sample as an example,

$$\text{RATIO} = \left[\frac{\text{RM}(1978) + \text{RES}(1978)}{\text{ACTIVE }(1978)}\right] \div 1{,}000$$

where

RM(1978) = the number of non-Native Saskatchewan Hospital Services Plan (S.H.S.P.) registrations in the same rural municipality as the physician as of June 30, 1978,

RES(1978) = the number of Native S.H.S.P. registrations living on reserves inside the rural municipality, and

ACTIVE(1978) = the number of physicians actively practicing in the municipality on December 31 of the sample year.

The value of RES(1978) had to be estimated as S.H.S.P. registers Natives by band, not by place of residence. From the Department of Indian Affairs and Northern Development, an estimate of the proportion of band members living on band reserves (denote by p) was obtained, so that RES(1978) was estimated by

RES(1978) = p X BAND(1978)

where

BAND(1978) = the number of band members registered with S.H.S.P. as of midnight June 30, 1978.

With regards to the counts of Native populations, two things should be noted.

Firstly, there was some double counting. In cases where a populated reserve straddled two rural municipalities, the estimated reserve population was included in both population counts.

Secondly, the value of RATIO has a downward bias. This resulted from the exclusion of Natives living off reserve from the population counts.

Finally, it should be noted that "active" physicians are not synonymous with "sampled" physicians. Active physicians were defined by sampling conditions S1 to S3, sampled physicians by conditions S1 to

S6. (Complete descriptions of the sampling conditions are given in the text of chapter IV).

Sources: a) Saskatchewan Hospital Services Plan, Covered Population (various years).

b) Department of Indian and Northern Affairs, "Registered Indian Population by Sex and Residence, for Band Districts, Regions and Canada" (unpublished tabulation prepared by the Department, December, 1979).

c) S.M.C.I.C., Physician Mobility File.

d) In cases where it was not clear which of a band's reserve land was populated either the band council or the district office of Indian Affairs were contacted for clarification.

10. P-ELD

To calculate this variable, it was assumed that the age distribution of Natives living on-reserve was equivalent to that for the band as a whole.

Sources: a) Saskatchewan Hospital Services Plan, Covered Population (various years).

b) Department of Indian and Northern Affairs, Registered Indian Population.

11. P-TOWN

Sources: a) Saskatchewan Hospital Services Plan, Covered Population (various years).

b) Department of Indian and Northern Affairs, Registered Indian Population.

12. BED1

Source: Saskatchewan Health (Policy Research and Management Services Branch), Index of Hospitals, Special Care Facilities, and Home Care Programs (Regina: Saskatchewan Health, July 1978 and 1979 eds.).

13. BED2

Source: Ibid.

# APPENDIX B

## COMMENT ON DATA SOURCES

Most of the data utilized in the study came from confidential files maintained by the Saskatchewan Medical Care Insurance Commission (S.M.C.I.C.) and the Saskatchewan Hospital Services Plan (S.H.S.P.). This appendix describes these sources, with particular attention being given to the Physician Mobility File.

File Descriptions

A) Bursary File (S.M.C.I.C.)

A card index which provides details on payments made under the Medical Scholarship and Bursaries Act (1963), which was described in chapter II. Information was used in the calculation of GRAD1. (Refer to appendix A).

B) Master Registration File (S.H.S.P.)

The file of beneficiaries registered under the province's hospital and medical care plans. This served as the source of information on family structure, ie. the variables FAM1 and FAM2. (Refer to appendix A).

C) Physician Mobility File (S.M.C.I.C.)

1. General Comments

a) File created in 1973.

b) Information obtained from i) the Saskatchewan College of Physicians and Surgeons, ii) a questionnaire filled out by physicians at the time of registration with S.M.C.I.C., iii) the S.M.C.I.C. Register of Physicians, and iv) correspondence with physicians.

c) A record is maintained for every physician registered with S.M.C.I.C. Records are not deleted when a physician, for whatever reason, ceases to provide services financed by the Commission. In other words, the file is an historical one, not simple file of current registrants.

2. Contents

a) S.M.C.I.C. Registration Number

b) Specialty

Note: This is the "nominal" specialty as determined by the Saskatchewan College of Physicians and Surgeons.

c) Sex

d) Year of Birth

e) Place of Graduation

Note: According to the first medical degree obtained.

f) Year of Graduation

g) Postal Code

Note: Doctor's mailing code as per S.M.C.I.C. files.

h) Clinic Number

Note: The following are the basic rules pertaining to the assignment of clinic numbers:

| | |
|---|---|
| 000 | Solo Practices |
| 000 - 599 | Associated Practices |
| 600 - 699 | Out of Province |
| 900 - 999 | Non fee-for-service |

i) Start Date
End Date

Note: The initial "Start Date" represents the physician's date of registration with S.M.C.I.C. Whenever there is a change in the physician's location, specialty, or clinic an "End Date" is specified. Changes in the physician's status are then recorded on a new line along with a new start date.

j) Location

Note: Simply the name of the village, town, or city in which the physician is located.

k) Urban/Rural Indicator

Note: The following breakdown is used.

R = rural (<10,000 population)

U = urban

T = rural, Swift Current Health Region

S = urban, Swift Current Health Region

l) Licence

Note: Indicates if the physician holds the Licentiate of the Medical Council of Canada.

m) Previous Location

Notes: i) Refers to the last pactice location prior to entering Saskatchewan.

ii) Type of practice in last location is also indicated, ie. either private practice, public health employee, teaching, intern, hospital based salary, or retired.

n) Cease to Practice

Notes: i) Indicates death, retirement, or departure from province.

ii) For physicians leaving the province, destination and type of practice at new location is also indicated.

APPENDIX C

TREATMENT OF CASES WITH MISSING VALUES

An important problem, common to many sets of sample data, is that of missing values. For the samples used in this study:

1) The age of the physician (AGE) was missing

   a) in two cases for the 1978 sample, and

   b) in two cases for the 1979 sample.

2) Information on family structure (FAM1 and FAM2) was missing

   a) in 16 cases for the 1978 sample, and

   b) in 18 cases for the 1979 sample.

One response to this problem would be to use only those cases with complete data vectors. This, however, would present two difficulties.

Firstly, one of the objectives of the study was to estimate the parameters of a particular function. Relative to the situation where there were no gaps in the data, estimation with only complete vectors would entail a loss of efficiency and, probably, result in some bias. The first problem would arise as long as the actual values for the missing data were not all equal to their respective sample means.[1] The second problem would arise if the missing values were not randomly distributed within the sample.[2]

Secondly, another objective of the study was to predict which physicians would leave a rural community over the course of a given year. The usefulness of this information would be greatly reduced if a large percentage of cases were excluded because of missing values.

As a result of these considerations, it was decided that an attempt would be made to estimate the missing values. The estimation procedures are described briefly below followed by an evaluation of their accuracy and reliability.

Estimation

1) AGE

Information on age (AGE) and years since graduation (YSG) was gathered for all general practitioners actively practicing in Saskatchewan during the fourth quarter of 1978. A linear relationship between these variables was then fitted, with the following results,

$$\widehat{AGE} = \underset{(.264)}{26.290} + \underset{(.014)}{1.009}YSG$$

$$n = 575;\ F = 5579.61;\ R^2 = .907$$

where

AGE = age, in years, on December 31, 1978, and

YSG = years since graduation on December 31, 1978.

This equation was used to estimate the values of AGE missing in the 1978 and 1979 samples. The results were then plugged into the data sets prior to the estimation of FAM1 and FAM2.

2) FAM1, FAM2

The following steps were carried out separately for the 1978 and 1979 samples:

a) Sampled physicians were allocated into groups A, B, C, or D according to

A; FAM1 = 0, FAM2 = 0

B; FAM1 = 1, FAM2 = 0

C; FAM1 = 0, FAM2 = 1

D; FAM1 = ?, FAM2 = ?

b) Using physicians with GROUP = A, B, or C, classification rules were developed for these three groups. These rules related family structure to the remaining independent variables used in the study.

c) According to the rules outlined in b), physicians from GROUP = D were classified into one of the remaining three groups.

The classification rules, estimates of which are presented in table C.1, were based on Mahalanobis' measure of generalized squared distance. The pooled covariance matrix was used and prior probabilities were assumed equal for all groups.[3]

Readers familiar with discriminant analysis will know that the conditions under which these rules are the best available[4] are violated in this application. However, their use was dictated by two factors.

Firstly, there is the general robustness of linear discriminant procedures. In terms of classifying observations with unknown group membership, these rules often perform as well as other, computationally more difficult, procedures.[5]

Secondly, there was the relative ease with which the procedure could be applied given its availability on a readily accessible software package.

Evaluating the Estimates

Any gains to be made through the estimation of missing values must be weighed against the losses arising from errors in measurement. These losses are dependent upon how closely the estimates approximate the actual values. It follows that an evaluation of the estimates should precede their use.

1. AGE

Assuming that the relationship between AGE and YSG follows the classical linear regression model, confidence intervals for the actual

TABLE C.1 : DISCRIMINANT FUNCTIONS FOR FAMILY STRUCTURE, 1978 & 1979

| VARIABLE | 1978 SAMPLE GROUP A | 1978 SAMPLE GROUP B | 1978 SAMPLE GROUP C | 1979 SAMPLE GROUP A | 1979 SAMPLE GROUP B | 1979 SAMPLE GROUP C |
|---|---|---|---|---|---|---|
| CONSTANT | -50.265 | -51.507 | -47.534 | -45.930 | -46.374 | -42.940 |
| AGE | 0.709 | 0.754 | 0.617 | 0.680 | 0.746 | 0.620 |
| SEX | 10.812 | 10.560 | 8.337 | 6.682 | 6.484 | 4.900 |
| GRAD1 | 5.643 | 3.763 | 1.671 | 4.606 | 5.277 | 3.774 |
| GRAD2 | -7.871 | -6.549 | -7.136 | -6.120 | -5.412 | -6.035 |
| GRAD3 | 1.428 | 1.896 | 2.355 | 3.407 | 3.821 | 3.946 |
| STAY1 | 10.340 | 9.234 | 6.882 | 11.657 | 11.009 | 8.085 |
| STAY2 | 3.220 | 3.657 | 1.496 | 6.152 | 5.596 | 4.998 |
| PRAC | 3.521 | 4.151 | 5.353 | 6.275 | 5.855 | 6.464 |
| DIST | 0.058 | 0.059 | 0.059 | 0.054 | 0.055 | 0.055 |
| GROWTH | 1.055 | 1.138 | 0.946 | 0.944 | 1.225 | 0.876 |
| RATIO | 8.435 | 9.013 | 9.255 | 6.450 | 6.386 | 6.699 |
| P_ELD | 1.980 | 1.883 | 2.089 | 1.645 | 1.581 | 1.731 |
| P_TOWN | 0.115 | 0.124 | 0.121 | 0.067 | 0.054 | 0.076 |
| BED1 | 0.632 | 0.481 | 0.467 | 0.464 | 0.299 | 0.311 |
| BED2 | -0.113 | -0.119 | -0.143 | -0.033 | -0.031 | -0.058 |

NOTES : 1) PRIOR PROBABILITIES WERE ASSUMED EQUAL .
2) GENERALIZED SQUARED DISTANCES BETWEEN GROUPS :

| GROUPS | 1978 | 1979 |
|---|---|---|
| A & B | 1.586 | 1.803 |
| A & C | 2.444 | 1.503 |
| B & C | 2.518 | 2.713 |

values of AGE were easily constructed.[6] These are provided below for the two cases in the 1978 sample with missing values for AGE.[7]

| Doctor | YSG | $\widehat{AGE}$ | Estimated Variance of Forecast Error | 90% Confidence Interval |
|---|---|---|---|---|
| A | 12 | 38.43 | 11.790 | 38.43 ± 5.65 |
| B | 19 | 45.49 | 11.788 | 45.49 ± 5.65 |

2. FAM1, FAM2

Estimates of the number of physicians whose family structure will be misclassified by the functions[8] presented in table C.1 were obtained in the following manner:

a) Physicians with known family structures were randomly assigned to one of ten samples denoted by S1, S2,...S10.

b) Classification rules were then calculated for all physicians not belonging to S1. These rules were used to classify the S1 physicians.

c) Finally, step b) was repeated for samples S2, S3,...S10.

The results from step b) were used to estimate the error rates. These are presented below:

| Group | Number Misclassified | Error Rate |
|---|---|---|
| 1) 1978 | | |
| - A | 15 of 29 | .517 |
| - B | 28 of 46 | .609 |
| - C | 47 of 157 | .299 |
| Total | 90 of 232 | .388 |
| 2) 1979 | | |
| - A | 23 of 36 | .639 |
| - B | 24 of 47 | .511 |
| - C | 44 of 144 | .306 |
| Total | 91 of 227 | .401 |

Conclusions

Given i) the strong relationship between AGE and YSG and ii) the tight distribution of the actual values about the predicted values, the use of $\widehat{AGE}$ appears to be a reasonable procedure. Because of this, all of the analysis made use of these estimates.

It should also be noted that the proportion of cases with missing values for AGE was very small, less than one percent in either sample. As a result, the impact of any errors in measurement will be minimal.

The same cannot be said of the variables FAM1 and FAM2. Physicians with unknown family structures made up about seven percent of the two samples. This, combined with the fact that the error rates were expected to be very high[9], suggested that estimates of FAM1 and FAM2 could seriously bias any analysis of the data. For these reasons, estimated values were used only in predicting whether or not a particular physician would leave a rural community over the course of a given year. They were not used, for example, in the estimation of the parameters for the prediction function.

## FOOTNOTES TO APPENDIX C

[1]J. Kmenta, Elements of Econometrics (New York: Macmillan, 1971), pp. 336-45.

[2]E. C. Jackson, "Missing Values in Linear Multiple Discriminant Analysis," Biometrics 24(1968): 835, and Lachenbruch, Discriminant Analysis, pp. 49-50.

[3]Lachenbruch, Discriminant Analysis, pp. 1-23 and 63-72.

[4]In general, optimal conditions for the use of linear discriminant rules require that the groups be exhaustive and mutually exclusive for the problem at hand. In addition, the independent variables must, within each group, be distributed multivariate normal with identical variance-covariance matrices. Refer to ibid.

[5]Refer, for example, to the studies cited in ibid., pp. 40-47. Krzanowski compared the performance of linear discriminant functions (LDF's) with the performances of classification rules derived from the location, logistic, and multinomial models. LDF's performed as well, or better, as the other procedures with exception of the location model. Refer to Krzanowski, "Discrimination and Classification Using Both Binary and Continuous Variables."

[6]Kmenta, Elements of Econometrics, pp. 239-42.

[7]It turned out that the same two physicians had missing values of AGE for the 1978 and 1979 samples. Estimates for the 1979 values, therefore, were simply obtained by adding one to the 1978 estimates.

[8]There are a number of ways to estimate error rates. For a discussion of some of the alternatives, along with an evaluation of their respective performances, refer to P. A. Lachenbruch and M. R. Mickey, "Estimation of Error Rates in Discriminant Analysis," Technometrics 10(1968): 1-11.

[9]This is especially true for groups A and B, namely, single persons and married couples without children. For both of these groups, the results suggest that an error will occur in over half the cases that are classified.

# APPENDIX D

# STATISTICAL PROCEDURES ASSOCIATED WITH THE BINARY LOGISTIC MODEL

This appendix outlines the statistical procedures employed in the study. Readers interested in a more extensive treatment of maximum likelihood estimation are referred to the works of Goldfeld and Quandt or Stopher and Meyburg.[1] Discussions of the logistic model and its applications may be found in Anderson, Cox, Day and Kerridge, Stopher and Meyburg, and Walker and Duncan.[2]

## The Model

The binary logistic model arises when there are two states, denoted by Y = 1 and Y = 0, which are exhaustive and mutually exclusive. The probability of observing a given state is assumed to be conditional on a set of variates[3], denoted by a 1xs vector X, according to

$$1)\quad P = Pr\{Y=1|X\} = \frac{\exp\{X\beta'\}}{1 + \exp\{X\beta'\}}$$

$$2)\quad 1 - P = Pr\{Y=0|X\} = \frac{1}{1 + \exp\{X\beta'\}}$$

where $\beta$ represents a 1xs vector of parameters.

The true value of $\beta$ is unknown and must be estimated from sample data. Samples, of size "n", can be represented by

$(y^1, x^1), (y^2, x^2) \ldots, (y^n, x^n)$

where

$y^i$ = the value of Y for the $i^{th}$ observation and

$x^i$ = the value of X for the $i^{th}$ observation.

There will also be occasion to refer to $p^i$, the probability of observing $y^i = 1$ given $x^i$. This is equal to

$$p^i = \Pr\{y^i = 1 \mid x^i\}$$
$$= \frac{\exp\{x^i \beta'\}}{1 + \exp\{x^i \beta'\}} .$$

Estimation

If each individual's decision with respect to Y is independent of the decisions of other individuals, then the probability of observing a given sample is

$$L(\beta;\ x^1,\ x^2, \ldots x^n) = \prod_i^n \{y^i p^i + (1 - y^i)(1 - p^i)\}$$

where L denotes the likelihood.

The likelihood can be viewed in two ways:

1) Where $\beta$ is known, L represents the true probability of observing a given sample.

2) Where $\beta$ is not known, L can be regarded as a function. For any possible value of $\beta$, L represents the probability of observing a given sample. (It should be clear that $\beta$ is now being treated as a vector variable. To avoid any confusion, the population, or true, value of $\beta$ shall henceforth be denoted as $\tilde{\beta}$).

Maximum likelihood estimation uses L in the second sense mentioned above. The goal is to find that value of $\beta$, say $\hat{\beta}$, such that the likelihood function is maximized. This can be done by solving the "s" equations,

$$\frac{\partial L}{\partial \beta} = \left[\frac{\partial L}{\partial \beta_i}\right]$$
$$= 0.$$

Alternatively, the log likelihood can be used. This is given by

$$\ell(\beta; x^1, x^2, \ldots x^n) = \ln L(\beta; x^1, x^2, \ldots, x^n)$$
$$= \sum_i \ln\{y^i p^i + (1 - y^i)(1 - p^i)\}$$

and the maximum likelihood estimates are given by solutions to

$$\frac{\partial \ell}{\partial \beta} = \left[\frac{\partial \ell}{\partial \beta_i}\right]$$
$$= 0.$$

Direct solution of this system of equations is not a simple matter. However, there are a number of indirect optimization techniques available.[4] In particular, the Newton-Raphson technique is frequently used and can be described as follows:

1) Start with an initial guess denoted by $\hat{\beta}(1)$.

2) The second estimate, $\hat{\beta}(2)$, is calculated as

$$\hat{\beta}(2) = \hat{\beta}(1) - f(1)F(1)^{-1}$$

where

$$f(1) = \left[\frac{\partial \ell}{\partial \beta_i}\right]_{\hat{\beta}(1)}$$

and

$$F(1) = \left[\frac{\partial^2 \ell}{\partial \beta_i \partial \beta_j}\right]_{\hat{\beta}(1)}.$$

3) From $\hat{\beta}(2)$, $\hat{\beta}(3)$ can be derived, and so on. In general, the $t^{th}$ estimate is given by

$$\hat{\beta}(t) = \hat{\beta}(t - 1) - f(t - 1)F(t - 1)^{-1}.$$

4) Iterations are continued until

$$\text{Max}\{\hat{\beta}(t) - \hat{\beta}(t - 1)\} < \delta$$

where $\delta$ is a "small" number.[5] This final estimator shall be denoted as $\hat{\beta}$.

## Statistical Tests and Procedures

### 1. Sampling Distribution of $\hat{\beta}$

For the binary logistic model,[6] the estimator $\hat{\beta}$ is asymptotically normally distributed with mean $\tilde{\beta}$ and variance-covariance structure

$$- \left[ \frac{\partial^2 \ell}{\partial \beta_i \partial \beta_j} \right]^{-1}_{\tilde{\beta}} .$$

Estimates for the parameters of the sampling distribution may be obtained as follows.

a) $\tilde{\beta}$ is consistently estimated by $\hat{\beta}$.

b) The variance-covariance matrix is consistently estimated by

$$- \left[ \frac{\partial^2 \ell}{\partial \beta_i \partial \beta_j} \right]^{-1}_{\hat{\beta}} .$$

### 2. Tests of Significance

For each value of $\tilde{\beta}$, the following test can be conducted:

$H_o: \tilde{\beta}_i = 0$

$H_1: \tilde{\beta}_i \neq 0$

The appropriate test statistic is given by

$$t^* = \frac{\hat{\beta}_i}{s.e.(\hat{\beta}_i)}$$

where $s.e.(\hat{\beta}_i)$ denotes the estimated standard error of $\hat{\beta}_i$.[7]

Under the null hypothesis, $t^*$ has a t- distribution with $(n - s)$ degrees of freedom. Therefore, $H_o$ is rejected with $100\ (1 - \alpha)\%$ confidence[8] whenever

$$|t^*| > t(\alpha/2,\ n - s)$$

where t denotes the tabulated value of the t- distribution.

3. Tests Involving Subsets of $\tilde{\beta}$

Given the alternatives

$\tilde{\beta} = (\tilde{\beta}_1 \; \tilde{\beta}_2 \ldots \tilde{\beta}_s)$

and

$\tilde{\tilde{\beta}} = \tilde{\beta}$, with $\tilde{\beta}_i = 0$ for some i, then the following test can be conducted:

Ho: True Model Involves

$\tilde{\tilde{\beta}}$

H1: True Model Involves

$\tilde{\beta}$

The appropriate test statistic is given by

$C = -2\{\ell_o - \ell_1\}$

with

$\ell_o = \ell(\beta; x^1 x^2, \ldots, x^n)|_{\hat{\hat{\beta}}}$, and

$\ell_1 = \ell(\beta; x^1 x^2, \ldots, x^n)|_{\hat{\beta}}$

where $\hat{\hat{\beta}}$ and $\hat{\beta}$ are the maximum likelihood estimators of $\tilde{\tilde{\beta}}$ and $\tilde{\beta}$.

Under the null hypothesis, C has a $\chi^2$- distribution with (s - r) degrees of freedom where r denotes the number of non-zero elements of $\tilde{\tilde{\beta}}$. Therefore, Ho is rejected with 100(1 - α)% confidence whenever

$C > \chi^2(\alpha, s - r)$

where $\chi^2$ denotes the tabulated value of the $\chi^2$- distribution.

4. Stepwise Selection of Variables

There are a variety of variable selection techniques which can be applied to the logistic model. A reasonably simple approach begins with model

$$P = Pr\{Y = 1\}$$

$$= \text{a constant value for all individuals in the population.}$$ [9]

Independent variables not contained in the model are then added according to the following scheme.

Step A - A variable is added to the model whenever the increase in the log likelihood arising from its addition is

i) larger than the increase arising from the addition of any other variable, and

ii) significant at a chosen confidence level. (The test used corresponds to that described under "Tests Involving Subsets of $\beta$").

If condition ii) is not met, then the selection procedure ends at this point.

Step B - Each variable included in the model is now tested using the t- test described earlier. If a variable tests as being insignificant then it is dropped from the model. If this corresponds to the variable that was just added, then the selection procedure ends at this point. Otherwise, the procedure returns to Step A.

# FOOTNOTES TO APPENDIX D

[1] S. M. Goldfeld and R. G. Quandt, Nonlinear Methods in Econometrics (Amsterdam: North Holland, 1972), chap. 2 and P. R. Stopher and A. H. Meyburg, Survey Sampling and Multivariate Methods for Social Scientists and Engineers (Lexington: D. C. Heath and Company, 1979), chap. 13.

[2] Anderson, "Separate Sample Logistic Discrimination;" Cox, "Some Procedures Connected with the Logistic Qualitative Response Curve;" Day and Kerridge, "A General Maximum Likelihood Discriminant;" Stopher and Meyburg, Survey Sampling and Multivariate Methods, chap. 15; and S. B. Walker and D. B. Duncan, "Estimate of the Probability of an Event as a Function of Several Independent Variables," Biometrika 54 (1967): 167-79.

[3] If a constant term is desired, then one of variates can be defined to be identically equal to 1.

[4] Golfeld and Quandt, Nonlinear Methods in Econometrics, chap. 1.

[5] Throughout the study, $\delta = 10^{-6}$ was used.

[6] The results reported in this section hold generally for maximum likelihood estimators provided that,

a) the likelihood function satisfies certain regularity conditions (eg. existence fo first and second-order partial derivatives), and

b) the estimator is sufficient.

Refer, for example, to Goldfeld and Quandt, Nonlinear Methods in Econometrics, pp. 63-4.

[7] Estimates of the standard errors are obtained by taking the square roots of the diagnonal elements of

$$-F|_{\hat{\beta}}^{-1} .$$

[8] Throughout the study $\alpha = .05$ was used. This included tests involving subsets of $\beta$ and tests carried out for the variable selection procedure.

[9] In models of choice involving modes of transportation this is known as the market shares model.