For Reference

NOT TO BE TAKEN FROM THIS ROOM
Ex libris
universitatis
Albertaensis

QUAECEMQUE VERA
THE UNIVERSITY OF ALBERTA

AN ECONOMIC ANALYSIS OF UTILIZATION PATTERNS IN ALBERTA HOSPITALS

BY

DAVID L. EMERSON

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF ARTS

DEPARTMENT OF ECONOMICS

EDMONTON, ALBERTA
FALL, 1970
The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for Acceptance, a thesis entitled AN ECONOMIC ANALYSIS OF UTILIZATION PATTERNS IN ALBERTA HOSPITALS submitted by David L. Emerson in partial fulfilment of the requirement for the degree of Master of Arts.
ABSTRACT

A great deal of concern has been generated over the past decade by the rising costs of health services. This thesis takes one portion of the Alberta hospital system and examines it in the context of economic theory and associated quantitative methods. Utilization patterns are analyzed through "a priori" theorizing, deduction and empirical testing of certain responsiveness indices.

The conclusions are that the Alberta hospital system is characterized by excess capacity and a preliminary argument is put forth for a rationalization of some hospitals in the system.
ACKNOWLEDGEMENTS

My deepest appreciation goes to my wife Doreen who, though effectively widowed for the past two years, has displayed considerable compassion and understanding for the problems of the graduate student.

I wish to thank Professor R. H. Plain for invaluable and in depth discussion and assistance. Further thanks go to L. S. Wilson and Marcel Benoit for their contributions to the research.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td></td>
<td>ACKNOWLEDGEMENTS</td>
<td>iv</td>
</tr>
<tr>
<td></td>
<td>TABLE OF CONTENTS</td>
<td>v</td>
</tr>
<tr>
<td></td>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>I</td>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>II</td>
<td>THE PROBLEM</td>
<td>4</td>
</tr>
<tr>
<td>III</td>
<td>SPECIFICATION OF THE MODEL</td>
<td>11</td>
</tr>
<tr>
<td>IV</td>
<td>THE ECONOMETRIC METHODOLOGY</td>
<td>22</td>
</tr>
<tr>
<td>V</td>
<td>THE EMPIRICAL RESULTS</td>
<td>30</td>
</tr>
<tr>
<td>VI</td>
<td>SUMMARY AND CONCLUSIONS</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>BIBLIOGRAPHY</td>
<td>60</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>ELASTICITIES WITH RESPECT TO BED AVAILABILITY</td>
</tr>
<tr>
<td>II</td>
<td>PER CAPITA BED AVAILABILITY IN CANADA BY PROVINCE</td>
</tr>
<tr>
<td>III</td>
<td>ELASTICITIES WITH RESPECT TO BEDS USED</td>
</tr>
<tr>
<td>IV</td>
<td>DUMMY VARIABLE ANALYSIS OF COVARIANCE FOR RURAL-URBAN CATEGORIZATION</td>
</tr>
<tr>
<td>V</td>
<td>ELASTICITIES WITH RESPECT TO BED AVAILABILITY - BY SEX</td>
</tr>
<tr>
<td>VI</td>
<td>ANALYSIS OF COVARIANCE BY AGE GROUP</td>
</tr>
<tr>
<td>VII</td>
<td>REGROUPED ELASTICITIES OF DIFFERENT AGE GROUPS</td>
</tr>
<tr>
<td>VIII</td>
<td>BEDS USED ELASTICITIES BY AGE GROUPS</td>
</tr>
<tr>
<td>IX</td>
<td>ELASTICITIES BY SELECTED DIAGNOSTIC CATEGORIES</td>
</tr>
</tbody>
</table>
CHAPTER I
INTRODUCTION
Spiraling costs of health services have created, over the past decade, a great deal of public concern regarding the sources of and solutions to the problem. Total net expenditure on health by all governments in Canada rose from $287 million in 1950 to $1,280 million in 1962.\(^1\) It is of particular interest to this study, to note that expenditures on hospital care alone have risen from $215 million in 1950 to $1,071 million in 1962.

More recently, Evans and Walker\(^2\) have noted that, during the sixties, Canadian health expenditures have been increasing at rates of between 10 and 15 percent. These same individuals indicate that such rising costs are made worse by the paucity of evidence which could indicate compensating "productivity" increases.

It has been purported by some economists\(^3\) that the problem stems from a chronic excess demand in the market for health services. This is not the theory adhered to in this thesis. In a market where a very large portion of the demand is created by medical practitioners it is of questionable value to refer to excess demand in the traditional sense.

---

\(^1\) Eric J. Hanson, *The Public Finance Aspects of Health Services in Canada*, Royal Commission on Health Services (Ottawa: Queen's Printer, 1963) p. 23.


Excess demand is generally associated with prices below an equilibrium level. Feldstein has made a strong case for discarding the excess demand theory by statistically verifying that demand for hospital services is largely a function of supply.  

The working hypothesis of this thesis is that the health services industry is characterized by gross inefficiency due to misallocations of resources both to and within the industry. Documentation of specific areas of inefficiency are provided by the Task Force Reports on the Cost of Health Services in Canada. The Task Force, although it abounds in specific cases of inefficiency, lacks an underlying model or framework. One objective of this thesis is to examine the hospital services industry vis-à-vis a perfectly competitive industry thus shedding light on the observed behavior in the former. This is dealt with in Chapter II. 

The next step, after having explored why the health services industry is not perfectly competitive, is to specify a theoretical model capable of rationalizing certain empirical manifestations of actual behavior. This involves the specification of a behavioral model which explains the nonprofit maximizing tendencies of hospitals. Chapter III undertakes this task in addition to deriving several testable hypotheses from the model.

---

4 See M. S. Feldstein, Economic Analysis for Health Services Efficiency (Chicago: Markham Publishing Co. 1968) Chapter 7.

The econometric framework for the empirical testing and description is specified in Chapter IV. Chapter V presents and interprets the statistical findings while a statement of the conclusions appears in Chapter VI.
CHAPTER II

THE PROBLEM
THE ALLOCATION PROCESS

The allocation of hospital services - like many other such problems involving scarcity - is appropriately dealt with in an economic framework. From the point of view of the province as a whole, the ultimate objective should be the provision of an "appropriate" quantity and quality of service through some implicit equating of marginal social costs and marginal social benefits.

It is convenient, for purposes of this study, to view this allocation process as occurring at two levels. At the provincial level the government attempts to arrive at an "optimal" allocation of scarce resources between various hospitals in the system. At the micro-level allocations must be made within a given hospital.

At the more aggregative level there can be associated with any government provision policy:\(^1\)

1. a set of available facilities - both those directly and indirectly controlled;
2. a pattern of utilization of facilities;
3. the associated costs - both those incurred by government and those paid by others;
4. the ultimate effect of this care on the health of the community.

It is clear that this can be interpreted as the

\(^1\text{M. S. Feldstein, Economic Analysis, p. 188.}\)
maximization (by the relevant government authority) of a social welfare function the arguments of which are measures of community health, the costs to the government and other costs. This maximization is subject to constraints imposed by the relationship between government provision, total availabilities, costs, utilization, and "health" of the community. That is, the government authority should attempt to equate marginal social benefits accruing to hospital services to marginal social cost.

The general problem is treated by Theil\(^2\) where he considers the decision-maker as attempting to maximize a quadratic preference function subject to a set of linear constraints.\(^3\) The arguments of the preference function comprise both controlled and uncontrolled variables (the former variables are those over which the decision-maker has some control). The constraints incorporate the uncontrolled variables as linear equations. The system is then solved by means of the Lagrangean technique which yields optimal values for both controlled and uncontrolled variables.

It should be noted that the above is merely a description of how the government, as a surrogate for the people, should attempt to conduct this particular allocation problem; it is not intended to describe the process actually used.


\(^3\)Theil is concerned, in this case, with decision-making under certainty.
Due to several exogenous restrictions, this thesis will deal with the less aggregative micro-type of model. First, there has been no attempt to analyze the effects of government provision policy on the way health resources are used. Second, there is no agreement on the way in which community health should be measured. Third, as a result of doctors viewing their problems as occurring under conditions of unconstrained maximization\(^4\) there has been little interest, on the part of the medical profession, in estimating opportunity costs of alternative methods of treatment.

A note on the afore-mentioned unconstrained behaviour of the medical profession is in order. Casual empiricism suggests that the product of most medical schools have an ingrained tendency to regard all his patients as deserving the best possible medical care. This tends to exclude the possibility of medical doctors consciously considering the economic opportunity costs of a given type of treatment for a given type of patient. Thus, doctors may admit certain cases to hospital which, if they were aware of the economic opportunity costs, they would not otherwise do. Again, policies such as the above could induce a consideration of opportunity costs so that adequate care could be provided for society at less cost.

This analysis considers government expenditures and supply programmes to be parametric while the designated var-

\(^4\)Unconstrained in the sense that the medical profession spares little to ensure their patients the best possible treatment.
variables will be associated with utilization patterns within the hospitals. Interest will be centred upon a set of hypotheses regarding how the variables can be expected to change with any given change in the supply parameter. The theoretical model will facilitate the derivation of hypotheses which can be tested against empirical data.

It is intended that the results of the study should have the potential to be presented to the appropriate decision-makers as a monitoring service. If such information can show the individual decision-makers could modify their behaviour so that the overall goals of the system are more nearly achieved, then it is conceivable that these people would alter their behavior in a desirable way.

The apparent emphasis on monitoring information can be justified when the nature of the decision-making unit of a hospital is made clear. The quotation marks about the term "administrator" are intended to remind the reader that no single individual can be considered the decision-maker for a particular hospital. The "administrator" is to be interpreted as a hypothetical individual whose behavior reflects the combined behavior of doctors, nurses (to a lesser extent)  

5The responsiveness indices to be used in this study will be elasticities which have several valuable properties to recommend them:

(a) they are pure numbers and as such are free from units of measure and scale considerations.

(b) elasticities are readily estimated in the form of slope coefficients when logarithmic transformations have been performed on the original data.
and the actual administrator. By far the largest component of the "administrator" are the doctors. It is the doctors who, by and large, decide whether a patient should be admitted to hospital and how long he should stay. The decision-making unit, being composed of "n" relatively independent individuals, could possibly be influenced by the provision of information designed to edify rather than command.

There are, however, other methods of exerting pressure on the relevant decision-makers. A judicious controlling of supplies (of hospital beds for example) can restrict the freedom with which patients can be hospitalized. A supply cutback, for example, could induce higher utilization rates and less hospitalization of certain cases for which it is not really necessary. Similarly, pressure could be brought to bear regarding lengths of stays.

The Inaplicability of the Competitive Model in the Health Industry

In a perfectly competitive setting such nonoptimal results are not a problem. Perfect competition, it is recalled, is premised by decentralized decision-making on the part of utility maximizing consumers and profit-maximizing producers. If certain behavioral and technical restrictions are imposed on the model\(^6\) and a price adjustment mechanism\(^7\)


is introduced, then there is assurance of the existence of a competitive equilibrium (having certain optimality properties) in addition to a mechanism capable of transforming disequilibrium situations into equilibrium situations.

Clearly, hospitals are not profit maximizers and further, to quote Feldstein:

The process by which hospital beds are distributed among types of patients and diagnoses ... is very different from the allocation of resources in the production of other consumer goods and services. The observed pattern of use cannot be regarded as the result of an optimizing process involving consumer's preference functions and the associated production possibility frontier. Although the patients are the consumers of hospital care, it is primarily the doctors who allocate hospital services ... Moreover, neither the patient nor the doctor is required to consider the financial or opportunity costs associated with a particular decision to consume hospital resources.

Thus, the market for hospital services is not characterized by the appropriate behavior of consumers and producers nor by the existence of a price adjustment mechanism. In the absence of the latter, although efficient allocations still exist, there is no assurance that they will be reached. Further, although individual doctors may be providing the best possible care for their patients (which may be optimal from both the doctors and patient's point of view) this does not imply that marginal social costs will be equated to

---


9 Feldstein, Economic Analysis, p. 190.
marginal social benefits in the provision of hospital services.

Thus, in order to explain present allocation practices in the health services industry it is necessary to discard the type of model premised by profit-maximizing producers. A behavioral model must be specified which will somehow simulate "who is maximizing what" in a hospital. Further, the variables dealt with in the maximization process must be specified (that is, the independent variables.) This task is undertaken in Chapter III.
CHAPTER III
SPECIFICATION OF THE MODEL
MEANINGFUL THEOREMS

In the Samuelson tradition\(^1\) meaningful theorems are defined as those which can conceivably be refuted (if only under ideal conditions.) Meaningful theorems derive from two general types of hypotheses:

(a) those where the conditions of equilibrium are tantamount to the maximization or minimization of some magnitude and

(b) those where the dynamic properties of the system are specified and the hypothesis is made that the system is in "stable" equilibrium or motion.

The latter hypothesis involves the use of the "correspondence principle" which explores the intimacy of the relationship between the stability problem and the derivation of fruitful theorems in comparative statics.

It is intended, in this analysis, to derive meaningful theorems from the former type of hypothesis. The comparative static method will be used to derive these theorems.

The Comparative Static Method

The method of comparative statics involves the designation of a set of variables for which solution values can be derived. Imposed on the variables are certain restrictions in the form of mathematical equations such that, when solved, will yield equilibrium values for the variables given a set

of parameters. The parameters (whose values locate the system in space) are defined when a closure is selected for the system.

The theoretical system under discussion will have, as parameters, the government supply programme and government expenditures on hospital services for any given hospital. It is of no small importance to realize that one parameter change, through interactions throughout the system, will result in an entirely new set of solution values for the variables. Comparative statics, then, involves the investigation of the changes in the solution values of variables resulting from changes in parameters.

**FORMAL SPECIFICATION**

It is postulated that "hospital administrators" adjust the number of cases treated ($N$), duration of stay ($S$) and quality of care ($Q$) in a way consistent with the maximization of a utility function:

$$ U = U(N, S, Q) .$$

The utility function is assumed to be cardinal and separable by a logarithmic transformation. To illustrate, the separability assumption suggests the utility function to be of a form such as:

$$ U = S^\alpha N^\beta Q^\delta $$

so that taking logarithms yields:

$$ \log U = \alpha \log S + \beta \log N + \delta \log Q $$

---

Thus, there is no problem identifying the separate effects of each variable. In addition this assumption implies no cross effects between elasticities taken with respect to utility.

Within the relevant range (defined by a set of constraints to be introduced) the marginal utilities: \(\frac{\partial U}{\partial S}, \frac{\partial U}{\partial N}, \frac{\partial U}{\partial Q}\), are assumed to be positive while the second order partials are negative (i.e. positive but diminishing marginal utilities). Further, it is assumed that the cross partials:

\[
\frac{\partial^2 U}{\partial S \partial N}, \frac{\partial^2 U}{\partial S \partial Q}, \frac{\partial^2 U}{\partial N \partial Q}
\]

are also positive and by Young's Theorem:

\[
\frac{\partial^2 U}{\partial S \partial N} = \frac{\partial^2 U}{\partial N \partial S}, \frac{\partial^2 U}{\partial S \partial Q} = \frac{\partial^2 U}{\partial Q \partial S}, \frac{\partial^2 U}{\partial N \partial Q} = \frac{\partial^2 U}{\partial Q \partial N}
\]

This latter condition ensures the Bordered Hessian will in fact be symmetric (the Hessian is bordered due to the constrained nature of the present maximization).

The first constraint is of the form:

(4) \( B = \frac{NS}{365} R \)

where \( B \) is the number of beds available in a given hospital, \( N \) and \( S \) are as before, and \( R \) is the proportional rate of occupancy and is fixed for a given hospital.

---

3 That is \( \frac{\partial^2 (\log U)}{\partial \log N \partial \log S} = \frac{\partial^2 (\log U)}{\partial \log N \partial \log Q} = \frac{\partial^2 (\log U)}{\partial \log S \partial \log Q} = 0 \)

The second constraint is a hospital budget constraint:

(5) \( E = NSD \)

where \( D \) is a constant elasticity cost function: \(^5\)

(6) \( D = AS^\alpha Q^\beta \)

\( A \) is a constant, \( S \) is duration of stay, \( Q \) is quality of care and \( \alpha \) and \( \beta \) are parameters. In the cost function it is assumed that the elasticity of cost per patient day with respect to duration of stay is negative and very small. \(^6\) That is, average cost per patient day actually declines as duration of stay increases.

Verbally, a given hospital must operate within the bounds specified by its budget allocation from the government. Average cost per patient day is defined by the specification in (6). (5) states that total expenditures for a given year cannot exceed \( E \), the budget allocation. Thus, "administrators" have their freedom restricted to varying \( N \), \( S \) and \( Q \) such that the equalities of (5) and (6) hold.

Quality, it should be pointed out, is a catch-all term to denote the general level of amenities provided to a patient. That is, it is a residual variable containing those components of the utility function other than \( N \) and \( S \).

Formally, the "hospital administrator" is assumed to maximize the constrained function:

(7) \( U^* = U(N,S,Q) + \lambda \frac{(NS - B)}{365} + \lambda \frac{NAS^{\alpha+1} Q^\beta}{365} - E \)

Matters can be facilitated by using lower case letters to

\(^5\) \( D \) is defined in terms of average cost per patient day.

\(^6\) This is born out by the estimate of \( \alpha = -0.192 \) by Feldstein for the British case.
represent the logarithmic transformation of the original variable:

\[(8) \quad u^* = u(n, s, q, r) + \mu_1 (n + s - \log 365 - r - b) + \mu_2 [n + (\alpha + 1)s + \beta q + a - e]\]

First order conditions for maximization of the Lagrangean are then:

\[(9) \frac{\partial u^*}{\partial n} = u_n + \mu_1 + \mu_2 = 0\]

\[\frac{\partial u^*}{\partial s} = u_s + \mu_1 + (1 + \alpha)\mu_2 = 0\]

\[\frac{\partial u^*}{\partial q} = u_q + \beta \mu_2 = 0\]

\[\frac{\partial u^*}{\partial \mu_1} = n + s - r - \log 365 - b = 0\]

\[\frac{\partial u^*}{\partial \mu_2} = n + (\alpha + 1)s + \beta q + a - e = 0\]

Assuming the equilibrium conditions to be fulfilled the system can be disturbed by arbitrary changes in parameters. This can be formulated into a system where the variables are now the changes in the variables concomitant with the changed parameters:

\[(10) \quad u_{nn} dn + d\mu_1 + d\mu_2 = 0\]

\[u_{ss} ds + d\mu_1 + (1 + \alpha) d\mu_2 = 0\]

\[u_{qq} dq + \beta d\mu_2 = 0\]

\[dn + ds = db\]

\[dn + (\alpha + 1) ds + \beta dq = de\]

This is written more concisely in matrix form:
Recalling the standard linear algebraic results and denoting the Bordered Hessian by $H$ and element $i, j$ of its inverse by $H^{-1}_{ij}$ the solution can be written:

\[
(11) \begin{bmatrix}
U_{nn} & 0 & 0 & 1 & 0 \\
0 & U_{ss} & 0 & 1 & 1 + a \\
0 & 0 & U_{qq} & 0 & \beta \\
1 & 1 & 0 & 0 & 0 \\
1 & 1 + a & \beta & 0 & 0 \\
\end{bmatrix}
\begin{bmatrix}
[dn] \\
[ds] \\
[dq] \\
[d\mu_1] \\
[d\mu_2] \\
\end{bmatrix}
= \begin{bmatrix}
0 \\
0 \\
0 \\
0 \\
de \\
\end{bmatrix}
\]

So that $dn$ and $ds$ are:

\[
(13) \quad dn = H^{-1}_{14}db + H^{-1}_{15}de
\]

\[
(14) \quad ds = H^{-1}_{24}db + H^{-1}_{25}de
\]

where, for example, $H^{-1}_{15} = \frac{|c_{51}|}{|A|}$

$|c_{51}|$ here is the cofactor of the element appearing in the fifth row and first column of the matrix of coefficients $[A_{ij}]$. $|A|$ is the determinant of the matrix of coefficients (see (11) above.)

The elasticity of the number of cases treated with respect to the number of beds available can be expressed as:

\[
(15) \quad \frac{dn}{db} = H^{-1}_{14} + H^{-1}_{15} \left( \frac{de}{db} \right)
\]
where \( \frac{de}{db} \) is the elasticity of budget expenditures with respect to the number of beds available.

The mean stay elasticity is similarly:

\[
\frac{ds}{db} = H^{24} + H^{24} \left( \frac{de}{db} \right)
\]

Calculating and simplifying the elements of the inverse matrix yields:

\[
\frac{dn}{db} = \begin{pmatrix}
\beta^2 u_{ss} + \alpha (1 - \frac{de}{db}) u_{qq} + \alpha^2 u_{qq}
\end{pmatrix} |H|^{-1}
\]

\[
\frac{ds}{db} = \begin{pmatrix}
\beta^2 u_{nn} - \alpha (1 - \frac{de}{db}) u_{qq}
\end{pmatrix} |H|^{-1}
\]

Formulation of the Basic Hypotheses

Ideally it would be desirable to employ what is referred to by Samuelson as "a calculus of qualitative relations" to deduce a set of testable hypotheses from the model. That is, from known signs of certain partial derivatives, be able to deduce the direction of change in the variables of interest associated with changes in parameters.

In equation (17) and (18) it is of interest to predict the sign of \( \frac{dn}{db} \) and \( \frac{ds}{db} \) given the direction of change indicated by \( \frac{db}{db} \). As it turns out, sign predictions can be made from the derivatives in question but they rely on economic intuition as well as known signs of partial derivatives.

From (17) the following sign configuration emerges:

---


\[
\frac{dn}{db} = \left( \beta u_{ss}^{(-)} + \alpha(1 - \frac{de}{db})u_{qq} + \alpha u_{qq}^{(-)} \right) \left| \frac{1}{H} \right|^{-1}.
\]

The expressions \( u_{qq} \), \( u_{nn} \) and \( u_{ss} \) represent the rates of change of certain elasticities resulting from infinitesimally small changes in the indicated variable. It is reasonable to suppose these are negative since increments in the variables would tend to create progressively smaller utility responsiveness. That is, one would tend to approach thresholds beyond which utility responds very little to increases in the respective variable. \( \left| \frac{1}{H} \right|^{-1} \) is negative by the second order conditions for the maximization which are assumed to hold.

It remains to anticipate the sign of \( \alpha(1 - \frac{de}{db})u_{qq} \). \( \frac{de}{db} \) is a measure of the extent to which the funds allocated to a hospital change in proportion to the number of beds available. Since government authorities presumably attempt to provide the same budget per available bed one would expect \( \frac{de}{db} \) to be approximately unity. Accepting this, the term \( \alpha(1 - \frac{de}{db})u_{qq} \) tends around zero and can consequently be disregarded.

Applying analogous reasoning for (18) the signs of the derivatives become:

\[
\begin{align*}
(19) \quad \frac{dn}{db} & > 0 \\
(20) \quad \frac{ds}{db} & > 0,
\end{align*}
\]

These are not really breathtaking since one would not expect, for example, an increase in bed availability to reduce either mean stay or cases treated.

A more subtle hypothesis can, however, be derived.
from the model. There is a reasonable "a priori" justification for formulating the following hypothesis: the elasticity of cases treated with respect to bed availability per capita is greater than the elasticity of mean stay with respect to bed availability per capita.

Intuitively, this asserts that the relevant decision-makers will tend to increase the numbers of patients they admit in response to a bed surplus relatively more than they increase lengths of stays of hospitalized patients. The following assertions loan credence to this hypothesis: 9

(a) there is the hospital physician's feeling of greater responsibility for the patient in his own personal care than for people who are waiting for admission

(b) there is the desire on the part of various types of medical people to "play it safe" or avert the risks associated with shorter lengths of stay

(c) the patients length of stay may, to some extent, be determined by the patient himself. This tends to make duration of stay less responsive to bed scarcity.

The first suggests that doctors whose patients are already in hospital will not vary their patient's length of

9These assertions appear in Feldstein, Economic Analysis, pp. 216-217. It should also be noted that although the hypothesis is couched in terms of increases in bed availability, the converse case of decreases in bed availability is also true.
stay greatly in response to bed scarcity. The second would mean that mean stays of patients are already relatively high (due to the risk-averting behavior of doctors) thus bed surpluses would not tend to increase patients' lengths of stay. The third is self-explanatory.

The conjecture has been made that:

\[
\frac{dn}{db} > \frac{ds}{db}.
\]

Necessary and sufficient conditions for \( \frac{dn}{db} > \frac{ds}{db} \) are derived by substituting (17) and (18) into (21):

\[
(22) \left( \beta u_{ss} + \alpha(a - de)u_{qq} + \alpha^2 u_{qq} \right) |H|^{-1} > \left( \beta u_{nn} - \alpha(1 - de)u_{qq} \right) |H|^{-1}
\]

The maximization of the utility function implies \(|H|^{-1}\) is negative so that:

\[
(23) \beta u_{ss} + \alpha(1 - de)u_{qq} + \alpha^2 u_{qq} < \beta u_{nn} - \alpha(1-de)u_{qq}
\]

\[
(24) \beta u_{ss} + \alpha(1 - de)u_{qq} + \alpha(1 - de)u_{qq} + \alpha^2 u_{qq} < \beta u_{nn}
\]

\[
(25) \beta u_{ss} + \alpha u_{qq} \left( 2(1 - de) + \alpha \right) < \beta u_{nn}
\]

\[
(26) 2\alpha \left( \left\lceil 1 - \frac{de}{db} \right\rceil + 0.5\alpha u_{qq} \right) < \beta \left( u_{nn} - u_{ss} \right)
\]

As before it cannot be proven that (26) will hold since known sign configurations do not yield an unambiguous answer. It is possible, however, to deduce why one might expect (26) to be true.

\(\alpha\), it is recalled, is assumed negative and very small. \(de\) is expected to tend around unity. The second order \(\frac{db}{db}\)
partials $u_{qq}$, $u_{nn}$ and $u_{ss}$ are negative.

Given these assumptions the expectation would follow that:

$$(27) \quad 2\alpha (1 - \frac{\partial e}{\partial b}) + \alpha^2 (u_{qq}) < 0$$

Since $\beta^2$ is positive it remains only to justify the conjecture that $u_{nn} > u_{ss}$. That is, the elasticity of utility with respect to duration of stay decreases at least as rapidly as the elasticity with respect to the number of cases. This result would be expected since duration of stay for most patients is already such as to minimize relapses. Thus the only source of utility gain from increased lengths of stay would be through the concommitant increase in the utilization rate. Increases in cases treated, however, yields gains in utility because of the increased utilization rate (which gives the appearance of efficiency and makes the hospital appear much used) and because of prestige gains associated with larger numbers of cases treated.

Thus, $\beta^2 (u_{nn} - u_{ss})$ is probably greater than zero and (26) would hold.
THE ECONOMETRIC MODEL

The analysis of Chapter III was carried out in the deterministic environment characteristic of many theoretical models. If one was sure that every conceivable variable and relationship were specified, the thesis could have ended at that point. As a matter of practical fact, however, one may be sure the specification is not entirely complete and that uninclude factors will tend to create observed disturbances from the model. Thus, in relating the model to the empirical world one must be ever-conscious of a stochastic component.

The technique used to relate the deterministic model to the empirical (and therefore stochastic) world will be linear regression analysis. The following assumptions are made with regard to the regression model:

(a) \( Y_i = \alpha + \beta X_i + e_i \)

(b) the \( e_i \) are independent random variables

(c) the mean of the \( e_i \) is zero

(d) the variance of the \( e_i \) is \( \sigma^2 \).

These assumptions are sufficient to ensure that the relevant estimators will be "best linear unbiased."

The use of regression analysis will also make it convenient to estimate elasticities directly in the form of slope coefficients after the variables have been logarithmically transformed. Specifically, one can estimate:
(1) \[ \log(S) = \hat{\alpha}_1 + \hat{\beta}_1 \log(A_1) + \log E_1 \]

(2) \[ \log(N) = \hat{\alpha}_2 + \hat{\beta}_2 \log(A_2) + \log E_2 \]

where \( S \) is mean stay, \( A \) is beds available per 1,000 population, \( N \) is cases treated per 1,000 population and \( E \) is the error term. Thus, the estimated elasticity of mean stay and elasticity of cases treated, with respect to per capita bed availability, will appear as \( \hat{\beta}_1 \) and \( \hat{\beta}_2 \) respectively.

Although the simple regression model will be sufficient to test the basic hypothesis derived in Chapter III, an extension to multiple regression analysis will permit other empirical questions to be answered. In particular:

(a) If beds are relatively scarce in a particular region, are there simply fewer cases treated or are the lengths of stay per treatment shorter?

(b) Are older or younger patients more affected by the scarcity of beds?

(c) Which types of patients - given certain diagnostic categories - are most affected?

TEMPORAL DIMENSIONS OF THE STUDY

The empirical analysis will be carried out on cross-sectional data for the year 1968. Several factors influence the choice of cross-section data as opposed to time-series:

(a) In Alberta there has, over the past decade and a half, been a significant rural-urban drift. Time-series data would tend to be influenced by this and would therefore require
very cautious handling.

(b) Technological change, over time, would tend
to render as variable those influences which
it is desirable to hold constant.

Cross-sectional data, on the other hand, ensures the
relative constancy of such exogenous forces and should con¬
sequently produce more reliable estimates.

SPATIAL DIMENSIONS OF THE STUDY

The universe of discourse from a spatial stand¬
point, is the Province of Alberta. Sample points are derived
from a set of regions wholly contained within the province.
The term "region" is considered synonomous with a "hospital
service area" so that the problem of defining a region reduces
to that of defining a hospital service area. It should be
noted that "hospital administration areas", as defined by the
provincial government, are not necessarily similar in any
way to those regions defined for the present study.

The regions in this study were drawn without over¬
lap, so that at least 85-90% of the actual users of the
facility are included. There is, of course, no restriction
on the hospital to be used by any particular Alberta resident
so there occurs a slight interregional drifting of consumers.
This type of drifting - in as much as it is between "rural"
areas - should tend to cancel itself out. Another drift, of
greater concern, is toward the larger urban hospitals which
provide more sophisticated treatment facilities for some
cases. Significance tests are carried out to examine whether or not such a drift significantly affects the results.

Problems were also encountered in the case of such atypical hospitals as Jasper, Banff and Slave Lake which tend to service a relatively large number of transient-type people, (skiers, oilworkers, etc.) Accordingly, these hospitals were removed from the sample.

In addition it was found virtually impossible to define service areas for certain city hospitals (whenever a centre had more than one hospital) since any attempt to appropriate population to hospitals in some proportion to hospital size would remove the variability in the supply variable. Clearly, good regression analysis requires a modicum of variability in the independent variables. Consequently, such hospitals were lumped into single statistical units serving the relevant metropolitan areas.

AN EXTENSION OF THE ECONOMETRIC MODEL

As indicated in Chapter II (footnote 5), primary concern is with the estimation of elasticities (responsiveness indices). Multiple regression on logarithmically transformed variables will facilitate the estimation of the relevant elasticities. Elasticity of mean stay and elasticity of cases treated with respect to bed supply will be estimated for the aggregated data, by age categories, by

1. This drift, if significant, would tend to create an upward bias in urban per capita bed supply.

2. See footnote 5 Chapter I.
diagnostic categories and by sex. Analysis of covariance (by the dummy variable method) will be incorporated into the model in order to test for significant variation between the categorical estimates.  

Two common methods of carrying out analysis of covariance tests are the Chow Test and the dummy variable method. The latter is to be preferred for several reasons:  

(a) If two regressions are different the Chow Test will show they are different without specifying the source of the differences. The dummy variable approach clearly points out the sources of the differences.  

(b) In just one regression one can obtain all the necessary information, whereas the Chow Test is a multi-stage procedure.  

Since two types of elasticities (mean stay and cases treated) are to be estimated there will be two regression equations each time the data is categorized. The regression for the diagnostic categorization will assume the general form:  

\[ \log S_{ij} = \hat{\alpha}_{s1} + \hat{\alpha}_{s2}(D_2) + \hat{\alpha}_{s3}(D_3) + \ldots + \hat{\alpha}_{sd}(D_d) \]  

3 Analysis of covariance, in this study, permits one to test whether a single elasticity estimate should be made for a large set of observations or whether a data categorization is desirable so that a number of estimates can be obtained (one for each discernable partition of the data.)  

\[ + \hat{\eta}_{s1} \log A_i + \hat{\eta}_{s2}(D_2) \log A_i + \ldots + \hat{\eta}_{sd}(D_d) \log A_i + \log E_{ij} \]

\[(2) \log N_{ij} = \hat{\alpha}_{N1} + \hat{\alpha}_{N2}(D_2) + \ldots + \hat{\alpha}_{Nd}(D_d) + \hat{\eta}_{N1} \log A_i + \hat{\eta}_{N2}(D_2) \log A_i + \ldots + \hat{\eta}_{Nd}(D_d) \log A_i + \log E_{ij}. \]

**NOTATION:**

\(\hat{\alpha}_{s1} = \) intercept estimate for diagnostic category 1; where \(s\) refers to mean stay being the independent variable.

\(\hat{\alpha}_{sj} = \) differential intercept estimate for category \(j = 2, 3 \ldots d; \) where \(d\) is the number of diagnostic categories.

\(\hat{\eta}_{s1} = \) slope estimate for diagnostic category 1.

\(\hat{\eta}_{sj} = \) differential slope estimate for diagnostic category \(j = 2, 3 \ldots d.\)

\(D_j = \) dummy variable used both additively and multiplicatively. \(D_j = 1\) for observations in category \(j(j = 2, 3 \ldots d)\) and is zero elsewhere.

\(E_{ij} = \) error term for observation \(i\) and category \(j.\)

\(N = \) number of cases treated per 1,000 population.

\(A = \) beds available per 1,000 population.

The terms "differential intercept estimate" and "differential slope estimate" will be made clear in one of the following illustrations.

\(5\) Recall that observations are across hospitals so that \(i\) refers to hospital \(i.\)
For diagnostic category 1 the mean stay regression would read:

(3) \[ \log S_{i1} = \hat{\alpha}_{s1} + \hat{\eta}_{s1} \log A_i. \]

It should be noted that the other terms in equation (1) disappear due to the dummy variables taking on zero values for this diagnostic category. Thus the estimated elasticity of mean stay with respect to per capita bed availability is \( \hat{\eta}_{s1} \).

For diagnostic category 2 the regression would read:

(4) \[ \log S_{i2} = \hat{\alpha}_{s1} + \hat{\alpha}_{s2}(D_2) + \{\hat{\eta}_{s1} + \hat{\eta}_{s2}(D_2)\} \log A_i. \]

Here the dummy variables 3, 4 ... \( d \) assume zero values while \( D_2 \) is unity. It is clear that to obtain the intercept and slope estimates for categories 2, 3 ... \( d \) it is necessary to add the coefficient on the relevant dummy variable to estimates for category 1. Thus, the coefficients on the dummy variables are referred to as "differential estimates".

Insertion of the dummy variables permits the hypothesis:

\[ H_0: \ \eta_{s1} = \eta_{s2} = \cdots \eta_{sd} \]

to be readily tested. This hypothesis is accepted if none of the estimated coefficients on the dummy variables are significantly greater than zero. If \( H_0 \) is accepted, it is concluded that a single regression across the pooled data

\[ ^{6}\text{This equation assumes that the coefficients } \hat{\alpha}_{s2} \text{ and } \hat{\eta}_{s2} \text{ are greater than zero for some given significance level.} \]
is satisfactory.

If, on the other hand, the null hypothesis is rejected it is concluded that a data categorization is desirable. Thus, running individual regressions for each of the categories explains significantly more of the variation in the dependent variable and hence provides a better elasticity estimate.

In addition one might test whether or not the slope estimate for category 1 is significantly greater than zero. This would be a straightforward application of the t test for a given level of significance.

Exactly analogous procedures can be applied each time a different categorization scheme is imposed on the data. The number of dummy variables would always be one less than the number of categories under consideration. The dummies would be similarly used in both the additive and multiplicative form. Testing procedures, again, would be strictly analogous.
CHAPTER V

THE EMPIRICAL RESULTS
EMPERICAL RESULTS OBTAINED FROM THE SIMPLE
REGRESSION MODEL

In specifying the econometric model the first step entailed setting up the fundamental regression equations:

1. \[ \log S_i = \delta_{si} + \hat{\gamma}_s \log A_i + \log E_i \]
2. \[ \log N_i = \delta_{Ni} + \hat{\gamma}_N \log A_i + \log E_i \]

where the notation corresponds to that employed in Chapter IV.

The objective was to estimate the following elasticities:

3. \[ \eta_s = \frac{\delta_s}{\delta A} \cdot \frac{A}{S} = \frac{d \log S}{d \log A} \]
4. \[ \eta_N = \frac{\delta_N}{\delta A} \cdot \frac{A}{N} = \frac{d \log N}{d \log A} \]

where \( \eta_s \) is the elasticity of mean stay with respect to per capita bed availability and \( \eta_N \) is the corresponding cases treated elasticity.

It should be noted that beds used is equal to the sum of the mean stay and cases treated elasticities. That is:

Beds used/1,000 population = (constant)(meanstay)(cases treated/1,000 pop.)

so that:

5. \[ \log B = \log K + \log S + \log N \]

Taking the differential and dividing through by \( d \log A \):

6. \[ \frac{d \log B}{d \log A} = \frac{d \log S}{d \log A} + \frac{d \log N}{d \log A} \]

or

7. \[ \eta_B = \eta_s + \eta_N \]

This simply means that: (1) the beds used elasticity
is a measure of the total effect on bed use of a change in per capita bed availability; (2) the total effect on bed use can be broken down into two components: that portion due to increased (or decreased) mean stay and that due to increased (or decreased) numbers of cases treated.

The elasticities along with other relevant information is recorded in Table I.

<table>
<thead>
<tr>
<th>ELASTICITIES WITH RESPECT TO BED AVAILABILITY</th>
<th>Estimate</th>
<th>t value</th>
<th>S.E.</th>
<th>d.f.</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Stay Elasticity</td>
<td>0.103</td>
<td>2.03*</td>
<td>0.05</td>
<td>99</td>
<td>0.04</td>
</tr>
<tr>
<td>Cases Treated Elasticity</td>
<td>0.593</td>
<td>8.12*</td>
<td>0.07</td>
<td>99</td>
<td>0.36</td>
</tr>
<tr>
<td>Beds Used Elasticity</td>
<td>0.696</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* t value significant at 2.5%

S.E. Standard Error

d.f. Degrees of Freedom

Recalling the three hypotheses of Chapter III;

\[
\frac{d \log N}{d \log A} > 0, \frac{d \log S}{d \log A} > 0 \text{ and } \frac{d \log N}{d \log A} > \frac{d \log S}{d \log A};
\]

it will be noted that all three are statistically verified in Table I. Both the mean stay elasticity and the cases treated elasticity are significantly greater than zero based on a one-tail test for a 2.5 percent significance level. Further, the cases treated elasticity is more than five times as large
as the mean stay elasticity.\(^1\)

The results compare favourably with those of Feldstein for a sample of British hospitals.\(^2\) Feldstein estimates the mean stay elasticity to be 0.365, the cases treated elasticity to be 0.580 and the beds used elasticity to be 0.947. The results of the present study suggest that a 10 percent increase (decrease) in per capita bed availability leads to a 6.96 percent increase (decrease) in per capita bed usage. In Feldstein's model the increase in bed usage is a high 9.47 percent. These responsiveness indices for bed usage can be broken up into a responsiveness for mean stay and a responsiveness for cases treated. In this study there will be an increase of 5.93 percent in cases treated which is closely matched by a 5.8 percent increase for the British case. The basic difference between the two beds used elasticities is a result of differing responsiveness indices for mean stay. In the Alberta system a 10 percent increase in per capita bed availability leads to a 1.03 percent increase in mean stay whereas the corresponding figure estimated by Feldstein is 3.65 percent.

\(^1\) It might be noted that the coefficient of determination is both equations is very low. Two factors may be cited to explain the casual acceptance of this fact:

(1) \(R^2\) is often low in cross-section studies because of the differing random elements affecting the observations associated with the individual economic units.

(2) In this study the testing of hypotheses is strictly a slope test and as such does not depend in any way on the value of \(R^2\).

\(^2\) Feldstein, Economic Analysis, p. 205.
Feldstein notes, with some dismay, that his cases treated elasticity is 50 percent greater than his mean stay elasticity. His dismay appears to find its origins in the idea that a high cases treated elasticity suggests that some people in "need" of hospitalization may not receive it if beds are in relatively short supply. Implicit in this is that there is a method for clearly delineating "need" for admission to hospital.

**TABLE II**

<table>
<thead>
<tr>
<th>PROVINCE</th>
<th>BEDS AVAILABLE PER 1000 POPULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newfoundland</td>
<td>6.03</td>
</tr>
<tr>
<td>Prince Edward Island</td>
<td>6.86</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>6.77</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>7.33</td>
</tr>
<tr>
<td>Quebec</td>
<td>6.86</td>
</tr>
<tr>
<td>Ontario</td>
<td>7.23</td>
</tr>
<tr>
<td>Manitoba</td>
<td>7.11</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>7.81</td>
</tr>
<tr>
<td>Alberta</td>
<td>9.54</td>
</tr>
<tr>
<td>British Columbia</td>
<td>7.10</td>
</tr>
</tbody>
</table>

In a hospital system such as Alberta's, where bed supply per capita is reportedly the highest in Canada, (as indicated by Table II) there is the distinct possibility of excess capacity. This is reinforced by the fact that the beds used elasticity in Alberta is only 0.696 compared with that of 0.947 in Britain. Thus, there appears to be substantially more demand for additional beds in Britain than is the case in Alberta. As further support for the excess capacity idea it is noted that the average utilization rate in Alberta is only 65
percent as opposed to 77 percent for the hospitals in Feldstein's sample. Finally bed availability per capita averages 5.42 in Feldstein's study as opposed to 9.54 in Alberta.

Given an excess capacity situation in the system and the behavioral model of Chapter III, there emerges a very reasonable explanation for the elasticities. "Administrators", in the process of maximizing utility, will tend to react to excess capacity by hospitalizing patients whose "need" for hospitalization can only be considered marginal. The term "marginal" is taken to mean that certain patients are hospitalized which would not otherwise be if beds were not so readily available. The marginal case would also be one for which treatment can be administered outside of the hospital. This is also consistent with profit-maximization by medical practitioners. A physician to quote Evans and Walker: ... "will view a hospital as free capital and labor which enable him to increase his output and productivity. Prices are fixed in the short-run; complimentary factors of

---

3 Although the statistical results hold for the system there is no reason to expect that the results will conclusively hold for all components of the system.

4 Which, it is recalled, is a composite of doctors, nurses and the actual administrator.

5 This is not necessarily inconsistent with medical ethics since the patient is probably getting the best treatment at the physician's disposal.

production are free; so he maximizes output per unit of (his own) labor."

Mean stays, however, would probably be relatively high already - given the relative excess capacity - so that "packing" by increased mean stays would be minimal. Thus, utilization rates and cases treated can be simultaneously stimulated by admitting more marginal cases when bed surpluses prevail. It should be noted that large numbers of cases treated per se may increase hospital prestige but maintenance of a reasonably high utilization rate may be a necessity in order to present a facade of efficiency, maintain budget appropriations and, more serious, to fend off the threat of closure.

In a system characterized by relatively great demand pressure (the British System) the need and/or desire to "pack" in order to maintain utilization rates becomes of marginal value. Although it may be true that the occasional bottlenecks are present in the Alberta hospital system, the assertion that patients actually in "need" of hospital care are being refused must be discarded. The fact of the cases treated elasticity being substantially greater than the mean stay elasticity appears to be largely explainable by a be-

---7See Chapter IV

---8This possibility is not at all remote as we note recent closures under similar circumstances in rural Saskatchewan.

---9This is reinforced by the fact of a lowly 65 percent utilization rate for the 100 hospitals in the sample.
behavioral tendency, in the system as a whole, to respond to bed surpluses by treating relatively more cases of marginal "need."

ELASTICITIES WITH RESPECT TO BEDS USED

The simple regression model was also used to obtain a set of elasticities for which beds used per capita is the explanatory variable. The results appear in Table III.

TABLE III
ELASTICITIES WITH RESPECT TO BEDS USED

<table>
<thead>
<tr>
<th></th>
<th>ESTIMATE</th>
<th>t</th>
<th>S.E.</th>
<th>d.f.</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Stay Elasticity</td>
<td>0.076</td>
<td>1.63*</td>
<td>0.05</td>
<td>99</td>
<td>0.03</td>
</tr>
<tr>
<td>Cases Treated</td>
<td>0.664</td>
<td>12.47**</td>
<td>0.05</td>
<td>99</td>
<td>0.6</td>
</tr>
</tbody>
</table>

* Significant at 10% in one tail
** Significant at 2.5% in one tail

It is noted that the elasticities of 0.076 and 0.664 for mean stay and cases treated respectively, do not differ appreciably from the previous estimates set out in Table I.

For purposes of this study, however, the beds available variable is to be preferred to the beds used variable. Beds used per capita tends to not only reflect differences in bed supply per se, but also the efficiency with which this
existing supply is utilized.\textsuperscript{10} It is argued that the use of this variable would tend to obscure the sought after relationship between physical bed supply and the utilization variables (mean stay and cases treated). Thus, the remainder of the study will treat beds available per capita as the supply variable.

Rural - Urban Results

In Chapter IV concern was expressed over whether the drift to urban hospitals for certain types of treatment would have a significant effect on the elasticity estimates. To test for this effect the hypothesis was set up that there is no difference between rural and urban estimates. In an attempt to refute this hypothesis a rural-urban dummy variable was incorporated into an analysis of covariance framework. Following the specification of Chapter IV the regressions:\textsuperscript{11}

\begin{equation}
\begin{align*}
(1) \quad \log S_i &= \delta_{S1} + \{\hat{\delta}_{S1} + \hat{\delta}_{S2}(D)\} \log A_i + \log E_i \\
(2) \quad \log N_i &= \delta_{N1} + \{\hat{\delta}_{N1} + \hat{\delta}_{N2}(D)\} \log A_i + \log E_i
\end{align*}
\end{equation}

were set up. The categorical variable, in this case, equals one for urban hospitals and zero elsewhere. The hypothesis to be tested reduces to whether or not the differential slope estimates are significantly different from zero. If they are, it is concluded that categorized estimates are preferable.

\textsuperscript{10}Beds used/1,000 population = Beds available/1,000 pop. X Utilization rate.

\textsuperscript{11}For notation see chapter IV.
These estimates are $\hat{\gamma}_{S1}$ and $\hat{\gamma}_{N1}$ for rural hospitals and $(\hat{\gamma}_{S1} + \hat{\gamma}_{S2})$ and $(\hat{\gamma}_{N1} + \hat{\gamma}_{N2})$ for urban hospitals. The results are recorded in Table IV.

**TABLE IV**

**DUMMY VARIABLE ANALYSIS OF COVARIANCE FOR RURAL--URBAN CATEGORIZATION**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Rural Elasticity Estimate</th>
<th>t value</th>
<th>S.E.</th>
<th>Urban Differential</th>
<th>t value</th>
<th>S.E.</th>
<th>d.f.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Stay</td>
<td>0.0995</td>
<td>2.026</td>
<td>0.05</td>
<td>2.013</td>
<td>1.59*</td>
<td>1.26</td>
<td>99</td>
<td>0.12</td>
</tr>
<tr>
<td>Cases Treated</td>
<td>0.595</td>
<td>8.08</td>
<td>0.073</td>
<td>-1.002</td>
<td>-0.53*</td>
<td>1.99</td>
<td>99</td>
<td>0.41</td>
</tr>
</tbody>
</table>

*t values not significant at 10%

The results indicate that there is not a significant difference between rural and urban elasticity estimates. Since statistics should not be considered absolute, it is noted that a significance level of 12 percent would have led to rejection of the null hypothesis regarding equality of mean stay elasticities. In this case the revised estimates would then indicate a mean stay elasticity of 2.11 for urban and 0.10 for rural hospitals.

It is useful to attempt to provide an explanation for the large differences in urban-rural estimates (that is, accept a 12 percent probability level and reject the null.) Casual empiricism suggests that there is relatively greater
demand pressure on urban as opposed to rural hospitals. It is noted that many rural hospitals were constructed to meet demands imposed on a particular region some years ago. Over the past several decades there has been a well-known rural-urban drift (particularly in the prairie provinces.) This would have the effect of shifting the individual demand curves of many rural hospitals in a downward direction. This trend is supported by the observation that the utilization rates for rural hospitals are around 65 percent as compared with 73 percent for urban hospitals. Additional support is obtained by noting that there are approximately 7.76 beds per capita in the rural vis-à-vis 7.02 per capita in urban hospitals.

Given two sets of hospitals characterized by differing relative demand pressures, one would expect a higher cases treated and a lower mean stay elasticity for the groups characterized by lower demand pressure. The results one obtains by establishing separate elasticity estimates for the rural-urban categories supports this argument. The urban results are approximately 2.0 and 0 for mean stay and cases treated elasticities respectively whereas the corresponding rural results are approximately 0.1 and 0.6.

It is important to note, from this discussion, that one must be very careful in interpreting these results. One cannot simply accept the null hypothesis yet the results are not decisive enough to conclusively reject it. Clearly, there is a need for a closer examination of rural versus
urban hospital.

ELASTICITY ESTIMATES CATEGORIZED BY SEX:

The model is set up in a manner exactly analogous to the specification for the rural-urban classification with the exception that the categorical variable now takes on values of unity for females and zero for males. The relevant results are tabulated in Table V.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Male Estimate</th>
<th>t</th>
<th>S.E.</th>
<th>Female Differential</th>
<th>t</th>
<th>S.E.</th>
<th>d.f.</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean stay</td>
<td>0.116</td>
<td>2.12</td>
<td>0.055</td>
<td>-0.047</td>
<td>-0.61*</td>
<td>0.08</td>
<td>199</td>
<td>0.04</td>
</tr>
<tr>
<td>Cases treated</td>
<td>0.652</td>
<td>8.57</td>
<td>0.076</td>
<td>-0.114</td>
<td>-1.06*</td>
<td>-1.06</td>
<td>199</td>
<td>0.04</td>
</tr>
</tbody>
</table>

* Not significant at 20%

Disregarding the insignificant differentials for a moment, the cases-treated elasticities of 0.652 for males and 0.538 for females compare favorably with Feldstein's estimates of 0.638 for males and 0.523 for females. The mean stay elasticities, however, are greatly divergent. Feldstein obtains 0.409 for males and 0.351 for females as compared with the present estimates of 0.116 and 0.069 respectively. These results are explainable when one considers the differing demand pressures on the British

12 op. cit. --. 205.
as opposed to the Alberta hospital systems. It was noted earlier in this chapter that Feldstein's beds-used elasticity, for the whole system was 0.947. This indicates, in general, that a 10 percent increase in bed availability generates a 9.47 percent increase in beds used per capita. In the Alberta system a similar proportionate increase in bed availability would result in only a 6.96 percent increase in per capita bed usage. It appears clear, then, that the British system studied by Feldstein is characterized by greater demand pressure than the present system. Following the reasoning of earlier sections one would not be surprised at the higher mean stay elasticities in the relevant part of the British system.

It is worth noting that, although Feldstein obtains numerous categorical estimates of elasticities, he performs no tests for significant differences between them.\textsuperscript{13} Male-female elasticity differentials in the present study, for example, are substantially greater than the differentials in Feldstein's estimates yet they do not differ to a significant extent. Although no positive assertion can be made, it is highly questionable whether Feldstein's do either.

The general conclusion of this section, then, is that a male-female categorization, at this level of aggregation, is not

\textsuperscript{13}Chapter VII of Feldstein contains a number of tables where elasticities were categorized simultaneously by sex and disease category and by sex and age category. Such breakdowns were not possible for the present study due to a insufficient breakdown of the relevant data by the hospital data collectors.
The multiple regression model was again employed to assess the significance of estimating separate elasticities for different age groups. Since five age groups were delineated, four dummy variables were needed: one for each age group except the 0 to 4 year olds.

The results, recorded in Table VI, indicate that mean stay elasticities do not differ significantly using a two-tailed test at 10 percent. Relaxing one's tolerance of type I errors to 20 percent, however, permits acceptance of a higher elasticity \((0.06 + 0.14 = 0.2)\) for the oldest group. This, of course, suggests that older patients tend to have greater mean stays in regions of greater per capita bed supply.

The null hypothesis; that all cases-treated elasticities are, for statistical purposes, the same; is rejected for a 10 percent level of significance. This indicates the need for a categorization of patients by age, into groups whose cases treated and mean stay elasticities are similar. The approach taken to this grouping was to form one group of elasticities for which the \(t\) values indicated a significant difference from the base group for a 10 percent significance level. The next group comprised those elasticities which were significantly different only when the significance level was dropped to 20 percent. The third group contained those elasticities which were not warranted.

**ELASTICITY ESTIMATES CATEGORIZED BY AGE GROUP**

The multiple regression model was again employed to assess the significance of estimating separate elasticities for different age groups. Since five age groups were delineated, four dummy variables were needed: one for each age group except the 0 to 4 year olds.

The results, recorded in Table VI, indicate that mean stay elasticities do not differ significantly using a two-tailed test at 10 percent. Relaxing one's tolerance of type I errors to 20 percent, however, permits acceptance of a higher elasticity \((0.06 + 0.14 = 0.2)\) for the oldest group. This, of course, suggests that older patients tend to have greater mean stays in regions of greater per capita bed supply.

The null hypothesis; that all cases-treated elasticities are, for statistical purposes, the same; is rejected for a 10 percent level of significance. This indicates the need for a categorization of patients by age, into groups whose cases treated and mean stay elasticities are similar. The approach taken to this grouping was to form one group of elasticities for which the \(t\) values indicated a significant difference from the base group for a 10 percent significance level. The next group comprised those elasticities which were significantly different only when the significance level was dropped to 20 percent. The third group contained those elasticities which were not warranted.

**ELASTICITY ESTIMATES CATEGORIZED BY AGE GROUP**

The multiple regression model was again employed to assess the significance of estimating separate elasticities for different age groups. Since five age groups were delineated, four dummy variables were needed: one for each age group except the 0 to 4 year olds.

The results, recorded in Table VI, indicate that mean stay elasticities do not differ significantly using a two-tailed test at 10 percent. Relaxing one's tolerance of type I errors to 20 percent, however, permits acceptance of a higher elasticity \((0.06 + 0.14 = 0.2)\) for the oldest group. This, of course, suggests that older patients tend to have greater mean stays in regions of greater per capita bed supply.

The null hypothesis; that all cases-treated elasticities are, for statistical purposes, the same; is rejected for a 10 percent level of significance. This indicates the need for a categorization of patients by age, into groups whose cases treated and mean stay elasticities are similar. The approach taken to this grouping was to form one group of elasticities for which the \(t\) values indicated a significant difference from the base group for a 10 percent significance level. The next group comprised those elasticities which were significantly different only when the significance level was dropped to 20 percent. The third group contained those elasticities which were not warranted.
### Table VI

**Analysis of Covariance (Dummy Variable Method) by Age Group**

<table>
<thead>
<tr>
<th></th>
<th>0-4 YRS.</th>
<th>t</th>
<th>S.E.</th>
<th>5-14 YRS.</th>
<th>t</th>
<th>S.E.</th>
<th>15-24 YRS.</th>
<th>t</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean Stay Elasticities &amp; Differentials</strong></td>
<td>0.06</td>
<td>0.87</td>
<td>0.07</td>
<td>0.032</td>
<td>0.33</td>
<td>0.096</td>
<td>-0.082</td>
<td>-0.85</td>
<td>0.096</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mean Stay Elasticities &amp; Differentials</strong></td>
<td>0.031</td>
<td>0.32</td>
<td>0.096</td>
<td>0.026</td>
<td>0.27</td>
<td>0.096</td>
<td>0.14</td>
<td>1.49</td>
<td>0.097</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cases Treated Elasticities &amp; Differentials</strong></td>
<td>0.360</td>
<td>3.1*</td>
<td>0.12</td>
<td>0.210</td>
<td>1.29</td>
<td>0.17</td>
<td>-0.0001</td>
<td>-0.01</td>
<td>0.17</td>
</tr>
<tr>
<td>Cases Treated Elasticities &amp; Differentials</td>
<td>Differential 25-44 yrs.</td>
<td>t</td>
<td>S.E.</td>
<td>Differential 45-64 yrs.</td>
<td>t</td>
<td>S.E.</td>
<td>Differential 65+ yrs.</td>
<td>t</td>
<td>S.E.</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-------------------------</td>
<td>---</td>
<td>-----</td>
<td>-------------------------</td>
<td>---</td>
<td>-----</td>
<td>-----------------------</td>
<td>---</td>
<td>-----</td>
</tr>
<tr>
<td>0.078</td>
<td>0.47</td>
<td>0.17</td>
<td>0.480</td>
<td>2.88*</td>
<td>0.17</td>
<td>0.583</td>
<td>3.18*</td>
<td>0.17</td>
<td>593</td>
</tr>
</tbody>
</table>

\[ t = t \text{ Value} \]
\[ \text{S.E.} = \text{Standard Error} \]
\[ \text{d.f.} = \text{Degree of Freedom} \]
\[ R^2 = \text{Coefficient of Determination} \]
\[ * \quad = \text{t Value Significant For a Two-Tail Test} \]
\[ \text{At a 10\% Significance Level.} \]
Significantly different at either of the above levels. The regrouped elasticities appear in Table VII.

TABLE VII

REGROUPED ELASTICITIES OF DIFFERENT AGE GROUPS

<table>
<thead>
<tr>
<th>CASES TREATED</th>
<th>ELASTICITY</th>
<th>MEAN STAY</th>
<th>ELASTICITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUP III</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-4 YRS.</td>
<td>0.36</td>
<td></td>
<td>0-4 YRS.</td>
</tr>
<tr>
<td>15-24 YRS.</td>
<td>0.36</td>
<td></td>
<td>5-14 YRS.</td>
</tr>
<tr>
<td>25-44 YRS.</td>
<td>0.26</td>
<td></td>
<td>15-24 YRS.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25-44 YRS.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>45-64 YRS.</td>
</tr>
<tr>
<td>GROUP II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-14 YRS.</td>
<td>0.57</td>
<td></td>
<td>65+ YRS.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GROUP I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45-64 YRS.</td>
<td>0.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>65+ YRS.</td>
<td>0.89</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An examination of Table VII indicates that the 65 and over group has the highest elasticities (both cases treated and mean stay) of all age categories. With regard to the cases treated elasticities both the 45-64 and 65+ group have very similar and very high responsiveness indices. This suggests that as one moves across regions there will be stronger tendencies to hospitalize older patients in areas of higher per capita bed supply than in areas of lower per capita bed supply. Although it is not as strong, there is a similar tendency to increased lengths of stay for the oldest group in

14 It should be noted that this is an extrapolation from the system as a whole to various regions in the system. In effect this comment may serve as a general rule of thumb but it is subject to severe limitations when it is applied to inter-regional trends.
regions of relatively great per capita bed supply.

The adolescent group (5-14 years) has an elasticity for cases treated which is significantly greater than that for 0-4 year olds when the significance level is dropped to 20 percent. This is perhaps a reflection of a tendency for adolescent diseases to be less acute than the type of diseases more strongly associated with the Group I age category.

In order to gain insight into the responsiveness of total bed usage by age group it is necessary to make use of the fact that the beds-used elasticity is the sum of the mean stay and cases treated elasticity. Table VIII records beds used elasticities for the various age groups.

**TABLE VIII**

**BEDS USED ELASTICITIES BY AGE GROUPS**

<table>
<thead>
<tr>
<th>AGE GROUP</th>
<th>ELASTICITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4 YRS.</td>
<td>0.42</td>
</tr>
<tr>
<td>5-14 YRS.</td>
<td>0.63</td>
</tr>
<tr>
<td>15-24 YRS.</td>
<td>0.34</td>
</tr>
<tr>
<td>25-44 YRS.</td>
<td>0.35</td>
</tr>
<tr>
<td>45-64 YRS.</td>
<td>0.93</td>
</tr>
<tr>
<td>65+ YRS.</td>
<td>1.09</td>
</tr>
</tbody>
</table>

Table VIII reveals an aggregative tendency for areas of relatively large per capita bed supply to permit relatively more bed use by patients in the older groups. In the 65 and over group a 10 percent increase (decrease) in per capita bed supply induces, on average, a 10.9 percent increase (decrease) in per capita bed usage by this group.

It must be noticed that the relationships indicated above can not be conclusively extended to any particular region.
The elasticities describe responsiveness patterns in a statistically representative hospital and therefore hold only for the system. Clearly there may be some regions where the results are strictly inapplicable. The next step, before any decisive micro policy statements can be made, is to extend the analysis so that elasticities for particular regions may be derived.

The results can be related to the purported tendency to hospitalize cases of a marginally serious nature when beds are in abundance. The estimates indicate those age groups for which hospitalization and lengths of stay tend to vary with bed availability. In consequence it is possible to identify the age groups for which "need" for hospitalization tends to be marginal.

ELASTICITY ESTIMATES BY DIAGNOSTIC CATEGORY

The last, and most horrendous task, was the application of the dummy variable method to the analysis of covariance for selected diagnostic categories. The multiple regression model was set up incorporating 2 equations (one for mean stay and one for cases treated) and 22 diagnostic categories (i.e. 21 dummy variables). Table IX presents the results in detail.

The fundamental hypothesis, that all mean stay elasticities are the same and that all cases treated elasticities are the same, is rejected for both the 10 and 20 percent level of significance. Thus one can conclude that a breakdown of elasticities by diagnostic category is desirable.
It will be noted that a number of the mean stay elasticities appear to be negative. It is an interesting exercise to attempt to establish an argument that would seemingly provide a possible basis for negative elasticity values. It is suggested that the sample itself may contain certain non-random patterns which tend to create the observed result. Specifically, there appears to be a tendency for larger per capita bed availability observations to be associated with smaller, more poorly equipped hospitals. This is a manifestation of the fact that rural hospitals tend to be smaller and more poorly equipped while simultaneously having higher per capita bed availability associated with them. The converse is true of urban hospitals so that as one moves across regions from those of low per capita bed availability to those of higher bed availability there is a tendency to move from better equipped and larger urban hospitals to smaller more poorly equipped rural hospitals. In such rural hospitals, however, there may be a tendency to admit patients for examination and then refer them to a larger urban hospital for treatment. This would tend to create, for certain diagnostic categories, the appearance of a lower mean stay in rural regions and hence could produce a negative elasticity.

15 Tests indicate that none of the mean stay elasticities are significantly less than zero at the 5 and 10 percent level. This implies that while the disaggregate results do not clearly support our aggregate hypothesis in every case (the hypothesis referred to is that the mean stay elasticity is greater than zero), one at least has the satisfaction of knowing that there has not been a reversal of the direction of change.
<table>
<thead>
<tr>
<th>DIAGNOSTIC CATEGORY</th>
<th>MEAN STAY ELASTICITY ESTIMATE</th>
<th>DIFFERENTIAL ESTIMATE</th>
<th>S.E.</th>
<th>t VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other infective and parasitic diseases</td>
<td>-0.127</td>
<td>--</td>
<td>0.103</td>
<td>-1.23</td>
</tr>
<tr>
<td>Malignant neoplasms</td>
<td>-0.027</td>
<td>0.0999</td>
<td>0.145</td>
<td>0.69</td>
</tr>
<tr>
<td>Benign neoplasms</td>
<td>-0.122</td>
<td>0.0496</td>
<td>0.146</td>
<td>-0.34</td>
</tr>
<tr>
<td>Allergic, endocrine system, metabolic and nutritional diseases</td>
<td>-0.013</td>
<td>0.1142</td>
<td>0.145</td>
<td>0.79</td>
</tr>
<tr>
<td>Diseases of ear and mastoid</td>
<td>0.108</td>
<td>0.2352</td>
<td>0.146</td>
<td>1.62*</td>
</tr>
<tr>
<td>Disease of circulatory system</td>
<td>0.046</td>
<td>0.1731</td>
<td>0.145</td>
<td>1.19</td>
</tr>
<tr>
<td>Disease of respiratory system</td>
<td>0.068</td>
<td>0.1949</td>
<td>0.145</td>
<td>1.34*</td>
</tr>
<tr>
<td>Disease of digestive system</td>
<td>-0.043</td>
<td>0.0841</td>
<td>0.145</td>
<td>0.58</td>
</tr>
<tr>
<td>Disease of urinary system</td>
<td>-0.039</td>
<td>0.0881</td>
<td>0.145</td>
<td>0.61</td>
</tr>
<tr>
<td>Diseases of genital system (including hyperplasia of prostrate)</td>
<td>0.016</td>
<td>0.1435</td>
<td>0.145</td>
<td>0.99</td>
</tr>
<tr>
<td>Diseases of skin and cellular tissue</td>
<td>0.138</td>
<td>0.2653</td>
<td>0.146</td>
<td>1.82**</td>
</tr>
<tr>
<td>Diseases of bone and organs of movement</td>
<td>-0.023</td>
<td>0.1040</td>
<td>0.145</td>
<td>0.72</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>-0.086</td>
<td>0.0407</td>
<td>0.145</td>
<td>0.28</td>
</tr>
<tr>
<td>Other allergic, endocrine, metabolic and nutritional diseases</td>
<td>-0.075</td>
<td>0.0524</td>
<td>0.145</td>
<td>0.36</td>
</tr>
<tr>
<td>Acute upper respiratory Infections</td>
<td>-0.064</td>
<td>0.0626</td>
<td>0.145</td>
<td>0.43</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>0.062</td>
<td>0.1897</td>
<td>0.145</td>
<td>1.31*</td>
</tr>
<tr>
<td>Arteriosclerotic and degenerative heart diseases</td>
<td>0.029</td>
<td>0.1558</td>
<td>0.145</td>
<td>1.07</td>
</tr>
<tr>
<td>Other diseases of the heart</td>
<td>0.106</td>
<td>0.2335</td>
<td>0.146</td>
<td>1.60*</td>
</tr>
<tr>
<td>Other diseases of respiratory system</td>
<td>0.089</td>
<td>0.2156</td>
<td>0.147</td>
<td>1.47</td>
</tr>
<tr>
<td>Appendicities</td>
<td>-0.032</td>
<td>0.0954</td>
<td>0.154</td>
<td>0.62</td>
</tr>
<tr>
<td>Other diseases of digestive system</td>
<td>-0.020</td>
<td>0.1069</td>
<td>0.146</td>
<td>0.73</td>
</tr>
<tr>
<td>Bronchitis</td>
<td>0.039</td>
<td>0.1661</td>
<td>0.145</td>
<td>1.14</td>
</tr>
</tbody>
</table>

con't
<table>
<thead>
<tr>
<th>DIAGNOSTIC CATEGORY</th>
<th>CASES TREATED ELASTICITY</th>
<th>DIFFERENTIAL ESTIMATE</th>
<th>S.E.</th>
<th>t VALUE</th>
<th>BEDS USED ELASTICITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other infective and parasitic diseases</td>
<td>0.663</td>
<td>--</td>
<td>0.105</td>
<td>4.03</td>
<td>0.536</td>
</tr>
<tr>
<td>Malignant neoplasms</td>
<td>0.581</td>
<td>-0.082</td>
<td>0.231</td>
<td>-0.35</td>
<td>0.554</td>
</tr>
<tr>
<td>Benign neoplasms</td>
<td>0.114</td>
<td>-0.549</td>
<td>0.233</td>
<td>-2.36**</td>
<td>-0.008</td>
</tr>
<tr>
<td>Allergic, endocrine system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metabolic and nutritional diseases</td>
<td>0.836</td>
<td>0.173</td>
<td>0.231</td>
<td>0.75</td>
<td>0.823</td>
</tr>
<tr>
<td>Diseases of ear and mastoid</td>
<td>1.142</td>
<td>0.479</td>
<td>0.231</td>
<td>2.07**</td>
<td>1.250</td>
</tr>
<tr>
<td>Diseases of circulatory system</td>
<td>0.734</td>
<td>0.071</td>
<td>0.231</td>
<td>0.31</td>
<td>0.780</td>
</tr>
<tr>
<td>Diseases of respiratory system</td>
<td>0.762</td>
<td>0.099</td>
<td>0.231</td>
<td>0.43</td>
<td>0.830</td>
</tr>
<tr>
<td>Diseases of digestive system</td>
<td>0.545</td>
<td>-0.118</td>
<td>0.231</td>
<td>-0.51</td>
<td>0.502</td>
</tr>
<tr>
<td>Disease of urinary system</td>
<td>0.827</td>
<td>0.164</td>
<td>0.231</td>
<td>0.71</td>
<td>0.788</td>
</tr>
<tr>
<td>Diseases of genital system (including hyperplasia of prostate)</td>
<td>0.519</td>
<td>-0.144</td>
<td>0.231</td>
<td>-0.62</td>
<td>0.535</td>
</tr>
<tr>
<td>Diseases of skin and cellular tissue</td>
<td>0.719</td>
<td>0.056</td>
<td>0.232</td>
<td>0.24</td>
<td>0.857</td>
</tr>
<tr>
<td>Diseases of bone and organs of movement</td>
<td>0.191</td>
<td>0.256</td>
<td>0.231</td>
<td>1.11</td>
<td>0.896</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>0.854</td>
<td>0.191</td>
<td>0.231</td>
<td>0.83</td>
<td>0.768</td>
</tr>
<tr>
<td>Other allergic, endocrine, metabolic and nutritional diseases</td>
<td>0.815</td>
<td>0.152</td>
<td>0.231</td>
<td>0.66</td>
<td>0.740</td>
</tr>
<tr>
<td>Acute upper respiratory Infections</td>
<td>1.021</td>
<td>0.258</td>
<td>0.231</td>
<td>1.55*</td>
<td>0.957</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>0.532</td>
<td>-0.131</td>
<td>0.231</td>
<td>-0.57</td>
<td>0.594</td>
</tr>
<tr>
<td>Bronchitis</td>
<td>0.790</td>
<td>0.127</td>
<td>0.231</td>
<td>0.55</td>
<td>0.829</td>
</tr>
<tr>
<td>Arteriosclerotic and degenerative heart diseases</td>
<td>0.614</td>
<td>-0.049</td>
<td>0.231</td>
<td>-0.21</td>
<td>0.643</td>
</tr>
<tr>
<td>Other diseases of the heart</td>
<td>0.716</td>
<td>0.053</td>
<td>0.233</td>
<td>0.23</td>
<td>0.822</td>
</tr>
<tr>
<td>Other diseases of respiratory system</td>
<td>0.812</td>
<td>0.149</td>
<td>0.234</td>
<td>0.64</td>
<td>0.901</td>
</tr>
<tr>
<td>Appendicities</td>
<td>0.407</td>
<td>-0.245</td>
<td>0.245</td>
<td>-1.05</td>
<td>0.375</td>
</tr>
<tr>
<td>Other diseases of digestive system</td>
<td>0.484</td>
<td>-0.179</td>
<td>0.232</td>
<td>-0.7</td>
<td>0.464</td>
</tr>
</tbody>
</table>

degrees of freedom for mean stay equation ... 2,183

degrees of freedom for cases treated equation ... 2,183

* significant at 20% in two-tailed test
** significant at 10% in two-tailed test
This explanation, clearly, is not intended to be conclusive but is merely offered as a possibility for further research and discussion. What is needed here is a more elaborate model perhaps utilizing among others, the knowledge of specially trained medical personnel.

From the table it is possible to break out a total index of the responsiveness of bed use to per capita supply with a further break out to indicate how much of the change in bed usage is attributable to varying mean stays and how much to varying cases treated. In the case of diseases of the ear and mastoid, for example, a 10 percent increase in per capita bed availability will induce a 12.5 percent increase in per capita bed usage by victims of such ailments in the "typical" hospital in the system. This can be broken out into an increase in cases treated of this type of 11.42 percent and an increase in mean stay of 1.08 percent. At the other extreme it is noted that a 10 percent increase (decrease) in per capita bed availability induces virtually no change in bed usage by victims of benign neoplasms.

Generally speaking, there are instances of what a layman might label appropriate elasticities and inappropriate elasticities. Appendicitis which one expects to demand immediate attention in most cases has an appropriately low total bed use elasticity of 0.375. This is broken into a mean stay elasticity of nearly zero and a cases treated elasticity of 0.407. Diseases of the ear and mastoid, on the other hand, has a fairly high bed usage elasticity of 1.25. Both the
mean stay elasticity and cases treated elasticity are relatively high at 0.108 and 1.142 respectively.

Examples of what one might consider inappropriate elasticities\(^{16}\) are those for malignant neoplasms and arteriosclerotic and degenerative heart disease. The bed-use elasticity for the former is 0.554 which is compared with a mean stay elasticity of -0.027 and a cases treated elasticity of 0.581. In the latter case the bed use elasticity is 0.643 and is broken down into a mean stay elasticity of 0.029 and a cases treated elasticity of 0.614.

It would be unwise and inappropriate to offer any behavioral explanations of the individual elasticity values since to quote Feldstein:\(^{17}\) "To do so properly, we should have to develop a complex theory of medical admissions and treatment decisions based on the factors that motivate patients to seek care and the way in which doctors diagnose and treat each type of disease."

\(^{16}\) Feldstein, *Economic Analysis*, p. 220 notes that the seriousness of these diseases is indicated by the fact that one-fifth of cancer patients and one-third of those suffering from arteriosclerotic and degenerative heart disease die in hospital.

\(^{17}\) *op. cit.* p. 221.
CHAPTER VI
SUMMARY AND CONCLUSIONS
SUMMARY

It was established in Chapter II that the allocation of scarce resources in the area of hospital services is not achieved by the price mechanism. In consequence, there was no reason to believe that the allocations would be such as to reflect economic opportunity costs. The fact that inefficiency is a problem is reflected by the statement of Evans and Walker: ¹

"Canadian health expenditures have been increasing at rates of between 10 and 15 percent for the past decade and in recent years have begun to accelerate. ... At the same time it is difficult to find evidence that Canadians are deriving any greater benefits from the industry in terms of increased health, well-being or productivity."

Hospitals being nonprofit institutions, ² there is little to be gained by models in which profits, sales or other such tangibles provide a motivating force. As an alternative it was found necessary to employ a model in which utility itself was the maximand. ³ It was then possible to derive a set of testable hypotheses regarding the way certain variables could be expected to change in response to change in a

¹Evans and Walker, "Public Policy Problems" p.
³The whole area of utility and utility functions has created extended controversy over the quantification problem. This is an area where an inter-disciplinary approach should be taken in order to utilize the skills of sociologists, psychologists etc.
parameter.

The following hypotheses were derived and tested:
(1) the elasticity of mean stay and elasticity of cases treated with respect to per capita bed availability is greater than zero; and (2) the cases treated elasticity is greater than the mean stay elasticity. The statistical results confirmed these hypotheses in aggregate although (not unexpectedly) hypothesis (1) was not born out for certain categorizations of the data.

CONCLUSIONS

A. SIMPLE REGRESSION MODEL

The explanation offered for the aggregative elasticities was based largely on the observation that the Alberta hospital system provided relatively more beds per capita than is the case either in Feldstein's British sample or in all other provinces in Canada.4

An integration of the excess capacity idea with the specified behavioral model led to the conjectured elaboration that observed utilization patterns may be largely the result of "administrators" tending to "pack" hospitals in areas where high per capita bed availability prevails.

Since probably the largest component of the "adminis-

4Evans and Walker, "Public Policy Issues," p. 8, provide outside support for the excess capacity idea by suggesting it's prevalence in much of Canada": "In the hospital industry...Canada has too many acute care hospital beds and other treatment facilities, a problem reflected in vacant beds, unnecessary admissions, and overly prolonged stays."
"trator" is medical practitioners it also appears true that at least that portion of observed demand which fluctuates with bed availability is essentially generated by the medical practitioners. Evans has made a similar point:  

"More realistically one could recognize that demand for hospital services is generated by medical practitioners who consult the relative costs and benefits of hospitalization to themselves and to their patients with weights that presumably vary from practitioner to practitioner."

B. MULTIPLE REGRESSION MODELS

It was possible to draw further general conclusions from several categorical breakdowns of the data. The rural-urban data categorization yielded tentative support (depending upon whether one accepts a 12 percent significance level) for the elaboration on the observed aggregative elasticities.

The results of the elasticity categorization by age group confirmed the basic hypotheses at this less aggregative level. The evidence also indicated that older people were the age group most affected by bed scarcity. In the case of the mean stay elasticity the 65 years and over group were associated with the highest elasticity. The responsiveness index for cases treated per capita indicated the 45 years and over group to be most elastic. This, of course, suggests that, where bed surpluses prevail, it has been found convenient to hospitalize older people more readily and retain them longer than is the case for other age groups.

5 Robert Evans, "Behavioral" Cost Functions for Hospitals, Discussion Paper No. 39, Department of Economics, University of British Columbia, p. 3.
Elasticities by diagnostic categories were also found to differ significantly from one another for both mean stay and cases treated elasticities. The economist can draw few conclusions in this area due to relative ignorance of the nature and treatment of the various ailments.

POLICY IMPLICATIONS

It was suggested in Chapter II that the results of the study might have the potential to be used as monitoring information. Effective monitoring information would influence the behavior of decision-makers in such a way that private gains would have to be sacrificed for public gains. The private gains in this case would be those associated with physicians employing, at no charge, the services of complimentary factors of production (services provided by hospitals) for the treatment of cases of a marginally serious nature. Such cases, from a social point of view, would probably be better dealt with using facilities (doctor house calls, public health clinics, more treatment in the doctor's office etc.) which the doctor himself must pay for or that are supplied by the public for reasons of economy. In the former case the burden is switched, to a greater extent, onto the doctors themselves thus inducing a greater cost awareness. In the latter case (of public health clinics) there is no private gain and there are presumably economies associated with intense usage of such a facility.

The prickly question here is whether monitoring information can be effective in inducing individuals to forego
private gains. If this is not so, then an alternative policy would be to reduce the supply of complimentary factors. This would likely mean a rationalization of some acute hospitals in favor of fewer hospitals of near "optimal" size and spaced for a judicious protection of the public interest. In terms of the number of beds available there would be an absolute reduction (in Alberta) and a per capita reduction in certain areas. Clearly such a policy would put more demand pressure on the remaining hospital facilities and thus impose pressures on decision-makers to curtail the admission of cases of marginal need. If these hospitals are at present operating on the downward-sloping portion of their short-run average cost curves then a overall expenditure reduction could be achieved.

With regard to urban versus rural hospital there appears to be two alternatives if one wishes an equalization of bed availability. One could advocate either a reduction in urban bed capacity or a decrease in rural capacity. Given that the rural-urban drift will likely continue for some years to come and that urban hospitals may be the source of some bottlenecks anyway, the overcapacitation of some rural hospitals threatens to get worse. It appears necessary to

6 Actually, even effective use of monitoring information should ultimately have this effect since facilities would then be even more underutilized and some rationalization of facilities would be called for.

7 This assumes that an equalization of opportunity (in terms of per capita bed availability) among different groups in the province is desirable.
take the alternative of actually reducing (or phasing out) a portion of the rural capacity. Contemporaneously it may be necessary (this question cannot be approached based on the results of this study) to expand urban capacity for certain types of treatment.

One can surmise, from the elasticity categorization by age group, a need for a strengthened program which will provide the appropriate quantity of treatment facilities for older people. More auxiliary hospitals and nursing homes might go far to free scarce resources in acute hospitals.\(^8\)

If supplies of acute hospitals are cut back to levels where demand pressures are greater on those remaining, natural forces will push some patients into the available facilities more specially designed for their needs.

**LIMITATIONS ON THE STUDY**

A. **SPECIFICATION**

It is clear that the various models employed here have not been particularly successful in explaining the majority of the variation in mean stay and cases treated. The bane of good explanatory models, a low \(R^2\), has been prevalent throughout much of the statistical section. In the traditional scheme of things this would probably be interpreted as a specification problem. However, there has been no pretension made that the dependent and independent variables in this study form a bivariate normal distribution. Consequently, to

\(^8\)It should be noted that Alberta, particularly since 1968, has taken concrete steps in this direction.
quote Fox:⁹

"There are other cases in which the original values of X and Y, or transformed ones, are distributed in something other than normal fashion; in these cases, we may still be a rough estimation of correlation in the universe, but we can no longer be sure that certain formulas appropriate to the normal distribution still apply ... In contrast, the interpretation of the regression coefficient ... is the same regardless of whether the X values are drawn at random or are subjected to purposeful selection."

While it is clear that, had one been interested in elaborate explanatory power for mean stay and cases treated, a much more comprehensive model would have been required; it remains true that the objectives of this study were not seriously affected.¹⁰

B. CONCLUSIONS AND IMPLICATIONS

It cannot be overstressed that the findings of this study apply to the system in aggregate. To get at more specific areas, research is needed in a number of areas. First, there is a need for a less aggregative (micro) type of study of utilization patterns. This might permit steps to be taken toward a standardization of medical treatment procedures. Second, there is great need for research into comparative efficiency of hospitals in this system. This should be approached through the theory of production and cost.


Estimation of long-run cost curves would provide insight to the question of "optimal" scale of operation. Short-run cost information would permit recommendations as to the desired intensity of operation for a hospital. Production theory and estimation could yield information on the problem of desirable factor mixes. Third and last, there appears to be a need for research into the desirable spatial orientation of hospitals in the system.

On completion of the above research a model can be assembled which can answer the following questions: (1) what is the optimal size of hospitals? (2) What is the optimal intensity at which such hospitals should be operated? (3) What are desirable factor mixes in hospitals? (4) Given the above information what is a desirable spatial pattern in the hospital system? It is only when such questions can be answered that one can broach the question of an optimal supply programme in the provision of hospital services.

It should be noted that a more elaborate micro study awaits the ready accessibility of data with detailed breakdowns. For purposes of this study it would have been desirable to have data breakdowns for individual hospitals of: cases treated and mean stay by sex, age groups and diagnostic categories. Although such breakdowns are available there is great loss of real resources in recovering it from government data tapes.
BIBLIOGRAPHY

ARTICLES AND PERIODICALS


BOOKS


Ezekiel, Mordecai; Fox, Karl A; Methods of Correlation and Regression Analysis (New York, John Wiley and Sons, 1965).

Feldstein, Martin S.; Economic Analysis for Health Services Efficiency (Chicago, Markham Publishing Co., 1968).


Canada, The Public Finance Aspects of Health Services in Canada, Royal Commission on Health Services (Ottawa, Queen's Printer, 1963).


Hanson, Eric J.; The Public Finance Aspects of Health Services In Canada, Royal Commission on Health Services (Ottawa: Queen's Printer, 1963) p. 23

UNPUBLISHED

Evans, Robert; "Behavioral" Cost Functions for Hospitals, Discussion Paper No. 38, Department of Economics, The University of British Columbia.

Evans, Robert; Walker, Hugh D. Public Policy Problems in the Canadian Health Services Industry, Discussion Paper No. 39, Department of Economics, University of British Columbia.

OTHER

Alberta, Government of Alberta Data Processing Division (Edmonton).