A MULTIPRODUCT APPROACH TO PHYSICIAN OUTPUT MIX.

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TO PHYSICIAN OUTPUT MIX

BY

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ABSTRACT

A MULTIPRODUCT APPROACH TO PHYSICIAN OUTPUT MIX

Budgetary restraints have forced a re-evaluation of expenditures for health care, regardless of the methods of delivery and financing. Efficiency in resource allocation implies production of an optimal output mix at minimum opportunity cost. Inefficiencies in resource allocation will result in higher costs. It is often argued that the fee-for-service reimbursement method, in particular, provides incentives for over-servicing, with elective surgery receiving most attention since international and intranational variations were out of line with variations in morbidity.

Although the initial concern of physicians was with the clinical risks of unnecessary surgery, concern with the rising costs of providing health care has turned attention to financial factors as possible explanations of the variations in elective surgical procedures. The physician plays a key role in the allocation of resources in the health care sector. It is, therefore, likely that the aggregate output mix of different services will be responsive to the differential relative benefit rates received by physicians, with a bias in favour of the more expensive procedures and the consequent higher costs for the system as a whole. The physician's key role is emphasized in this study with the

emphasis on supplier incentives and the inherent multiproduct nature of health care output.

Economic theory predicts a movement along the production possibility frontier in output space in response to relative price changes. Econometric estimation of multiproduct production relations has been facilitated by the application of duality theory and the development of flexible functional forms. Duality theory establishes that the parameters of the production function can be represented equally well by the corresponding dual profit or cost function. Flexible functional forms for the profit function permit derivation of supply equations with relative prices as independent variables.

Four elective surgical procedures were selected in order to estimate the aggregate substitution in production by physicians. With pooled cross-section and time series data for Canada for the period 1973 to 1981, the supply equations were estimated as a system, using the SURE estimation technique. Supply elasticities for price changes and changes in the key fixed factors were calculated. While emphasis was on the price response, the functional form incorporated the constraints imposed by the availability of hospital beds and surgical specialists.

Evidence was found in support of the view that physicians allocate their time partly in response to changes in the prices of elective procedures relative to other procedures. With global budget constraints imposed on hospital expenditures, the four procedures, being elective, might possibly be given lower priority. Also, the estimated coefficients for the lagged dependent variables suggest that an inertia model of adjustment applies. Although incentives may exist in the fee structure to substitute toward the more expensive procedures, the results suggest that, at least for the period of the study, substitution was not on the basis of price alone, and that resource constraints, as proxied jointly by the number of hospital beds and surgical specialists, play a greater role in determining _aggregate_ output.

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DEDICATION

I wish to dedicate the thesis to my parents: Julia Waples and the late Leo Raymond George Waples.

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CHAPTER ONE

INTRODUCTION

Decisions regarding optimal resource allocation in health care must be made in the light of output objectives regardless of the method of delivery of health services and their financing. Neoclassical production theory provides a framework for the determination of optimal resource allocation. On the supply side, efficiency in the usage of inputs results in the production of output at minimum resource cost, with the behavioural postulate of profit maximization being the dual of cost minimization. Efficiency in input mix also implies an optimal output mix in response to relative prices.

Concern with absolute cost levels of the Canadian health care system and the resulting budget constraints have meant closer scrutiny of the allocation of funds within the health care budget. The possibility that incentives within the health care system are giving rise to inefficiencies in resource allocation has been addressed. Such incentives may manifest themselves as a tendency of more services of a certain category being provided than is warranted by pathological conditions, with a bias occurring in favour of the more costly procedures.

Large international and intranational variations in elective surgical rates were reported which could not be explained by differences in morbidity patterns. A number of reasons cited as explanations for over-servicing have a direct bearing on financial incentives; a major one is the method of payment of physicians. The fee-for-service system in particular provides strong incentives for over-servicing, especially regarding elective surgical procedures. Since the developments of diseases for which elective surgery is a treatment option are often associated with lifestyle factors, there is scope for legitimate doctor discretion in determining treatment. Nonsurgical options are available and in the majority of cases, delay of the operation does not constitute a threat to life.

Once the patient has initiated contact with the health care system, the physician plays the key role in directing the allocation of resources. Under universal public health insurance, a major economic constraint for the patient is removed. Since most subsequent decisions regarding health care are thus supplier driven, the focus of which incentives contribute to a particular output mix turns to the supply side.

Relatively higher marginal revenues from some services are an incentive for over-servicing. To explain patterns of surgical rates it is necessary to focus on the "production" decision of physicians and the role played by prices and technology. Generally, consumers are not likely to have the option of substituting between different operations in the way they substitute among other goods and services as prices vary. Physicians, however, are likely to respond in the allocation of their time in ways similar to other entrepreneurs in allocating productive factors. Time will be allocated among the different discretionary procedures in order to maximize profit. The model based on standard maximizing behaviour for the theory of the firm is applicable in modelling output decisions in the medical care market, despite alleged divergences from the perfectly competitive model.

Changes in output mix can be represented as movements along the physicians' production possibility frontier. Physicians, viewed as firms, are inherently multiproduct producers if only because of the need to allocate their time between different procedures. To the extent that the more remunerative procedures are substituted, a more expensive case mix, and higher health care costs, may result. Key responses to changes in relative prices that result in a change of output mix cannot be analysed with single output measures nor with case mix approaches to cost differences. Prices other than those of each given elective surgical procedure must be incorporated into the supply equations to be estimated.

Estimation of the underlying production function from which supply equations are derived is not always possible due to the lack of data on intermediate inputs. Further, knowledge of the production function is not usually useful for itself, but for the evaluation of the effects of price changes. The principles of duality theory and development of flexible functional forms have greatly facilitated the econometric estimation of the required parameters. Duality theory establishes that the two approaches for deriving the profit maximizing output quantities are equivalent. Instead of applying Lagrangian maximizing techniques to the production function and inverting the first order conditions, differentiating a profit function will yield supply equations which represent the firm's technology, providing that the profit function exhibits mathematical properties consistent with the economic theory of the firm. In order to estimate supply equations with relative prices as independent variables, the choice of functional forms for the profit function must be from a class that gives a second order approximation to that function. Ease of econometric estimation in the light of cost constraints on computer use must also be considered in choosing a functional form. This factor limited the number of elective surgical procedures that were eventually considered. The four elective surgical procedures, all within the "major surgery" category are haemorroidectomies (HM), herniorraphies (IH), cholecystectomies (CH) and hysterectomies (HT).

The objective of the study is to determine the extent of substitution in output space in response to changes in the relative benefit rates of the four elective surgical procedures. A weighted price index for all the other procedures is constructed, based on service intensity. In addition to own-price elasticities and cross-price elasticities within the four procedures selected, the cross-price elasticities with respect to all other medical procedures, including other surgery are calculated. Elasticities (short-run and long-run) are also calculated with respect to the key fixed inputs in the supply equation, hospital beds per thousand population and surgical specialists per thousand population.

A selective review of the literature pertaining to surgical rate variations is provided in Chapter Two, indicating various responses to financial factors as explanations for the international and intranational variations in elective surgical rates. The institutional setting, itself a response to previous problems and incentives, determines the incentive structure to which providers respond. Although a major objective of Canadian health insurance was to ensure access to requried health care, doctors' interests in particular were met within this constraint; the major concession was the retention of fee-for-service as the method of remuneration. The fee-for-service mode is alleged to provide greater incentive towards over-servicing. Since changes of individual benefit rates for different procedures and for different medical specialties has been left to the profession, there is scope for the fee structure to affect changes in output mix over time.

Trends in health care costs and price and quantity data for Canada covering the period 1973-1981, which comes after the adoption of medicare, are presented in Chapter Three. The key price variables are the provincial benefit rates and indexes of these rates are presented. In addition, an explanation of the construction of the price index representing other surgical procedures and consultations that compete for the physician's time is given. Although the indexes of benefit rates relative to the price index of other procedures do not show extensive variation, analysis of coefficients of variations with respect to relative prices within the major surgical category indicates sufficient variation to warrant further investigation as to the effect of changes in the fee structure on surgical output mix.

The multiproduct nature of health care output is clear from observation of the operation of hospital activities. Although there have been a number of studies recognizing the multiproduct nature of hospital output and confirming the importance of case mix on hospital costs, these studies have focused on the hospital as supplier, rather than on the role of relative prices in the physicians' incentives to provide a given output mix. In addition to reviewing the multiproduct nature of health care output, Chapter Four considers the criticisms of the traditional economic model as a basis for analysing aggregate output response. A simple utility maximizing model explaining the allocation of time to leisure and services is presented. Since leisure is constant over time, the allocation of time over professional activities may be modelled as profit maximizing behaviour. The specification of a multiproduct profit function for surgical output mix is then discussed, with modifications appropriate to the Canadian health care system.

The principles of production duality establish that the parameters of the supply equations derived from the profit function are equivalent to those derived with more difficulty from the production function. Duality theory and the development of flexible functional forms allows estimates of the underlying parameters to be derived despite severe data constraints and lack of knowledge regarding the specification of the original production technology. Chapter Five outlines the mathematical properties required of the profit function in the context of duality theory. Criteria involved in the selection of functional forms that give regard to the testing of the hypotheses underlying the model and to the econometric considerations in the estimation of large numbers of parameters are stated. The application of Hotelling's lemma to derive supply equations from the profit function facilitates econometric estimation.

Chapter Six presents the results of the multiproduct estimation for surgical supply equations. The equations were estimated on a per thousand population basis to allow for the different sizes of the provinces. Preliminary testing of price responses was conducted with ordinary least squares. The chapter reports only those forms that include relative price terms in a form consistent with subsequent estimation using the translog and the generalized Leontief profit functions. The ordinary least squares results suggest that there is some price-induced substitution. Econometric techniques to correct for multicollinearity did not alter the estimated coefficients materially. Further, the presence of autocorrelation suggested that Generalized Least Squares (GLS) would be a more appropriate estimator than Ordinary Least Squares (OLS). Since the estimates obtained from the translog estimates were unsatisfactory, the results of this study are summarized in terms of the estimates derived from the generalized Leontief variable profit function. A dynamic specification was incorporated by the inclusion of the lagged dependent variable in each supply equation. Since benefit rates are negotiated annually, a one-year lag was appropriate.

For the four elective surgical procedures, supply was inelastic with respect to own-price and cross-prices. Since the slope of the production possibility frontier in output space is low, the opportunities for substitution appear limited. The provincial variations in relative prices were incorporated by attaching the dummy variables to the price index term representing all other procedures. More substitution in production of each of the elective procedures was evident with respect to changes in this weighted price index. However, the major factor in explaining output responses was the availability of key fixed factors, particularly hospital beds per thousand population. The lagged dependent variable also accounted for a significant variation in the supply, suggesting that an inertia model of adjustment is appropriate for the supply of the four operations selected.

A summary and some concluding comments are presented in Chapter Seven. Subject to data limitations, it would appear that the scope for substitution within the four elective surgical procedures selected is limited, with the availability of hospital facilities being the major constraint, at least for the nine-year period considered. However, the estimates suggest that more scope exists with regard to substitution between each elective surgical procedure and other surgical procedures collectively. Since the output responses to price changes are inelastic, cost control measures directed at both hospital bed availability and relative prices are likely to be more effective than policies based strictly on relative prices.

CHAPTER TWO

ECONOMIC INCENTIVES AND ELECTIVE SURGICAL RATES

2.1 INTRODUCTION

Trends in utilization and health care costs are influenced to a significant extent by the health services delivery system (private or public), its method of financing (public or private insurance) and the system of remunerating doctors. Whatever the methods of delivery and financing, certain economic incentives will be present, which will in turn have a bearing on the mix of services provided. Not all the incentives will result in an efficient allocation of resources. Trade-offs will be inevitable. It has been suggested that the incentives operating under a universal public health insurance system with fee-for-service remuneration may encourage an over-provision of services in terms of the health requirements indicated by morbidity data. Such an over-provision may contribute substantially to higher costs.

Given the high cost of surgery and the risk of death (even with elective procedures), surgical service rates have attracted considerable attention. Initial concern by physicians focused on the clinical risks associated with surgery performed where disease incidence did not warrant it. Variations in surgical rates were greatest for "elective" surgical procedures; differences in morbidity patterns did not explain the greater variations in elective surgical rates across countries and within countries[1]. With universal health insurance a major price barrier on the potential patients' part is removed and it is appropriate to emphasize supplier incentives in issues of economic efficiency.

Although the 1957 Hospital Insurance and Diagnostic Services Act achieved universal public hospital insurance[2], with all provinces joining by 1961, the introduction of hospital insurance ten years before the establishment of universal medical insurance provided incentives to favour in-patient care, which is more costly than out-patient care.

The physician, who bears no part of the direct costs for hospital resources, plays the critical role in determining their use. The physician decides on admission, length of stay, procedures and drugs used, and referrals. Specialists determine surgical procedures, subject to urgency and the availability of operating room facilities. LeClair (1975) estimated the costs associated with such decisions to be 80 per cent of health costs (p.79). The financing mechanism plays a key role in affecting the incentives faced by the suppliers in the health care system. The emphasis is on supply since "...the level and mix of health services used is more sensitive to levels of supply and to the professional and economic objectives of providers..." (Evans, 1984, p.99). Given the importance of such decisions, it is important to consider the evidence of responses of the key decision makers to major economic incentives.

There had been considerable controversy surrounding the government's decision to provide national medical insurance[3]. Medical insurance was seen as a greater threat to physician autonomy in pricing and servicing patterns than was hospital insurance. In fact, Evans (1984) claims that "...(the) self-regulatory power of providers...has been used to influence insurance markets so as to encourage the spread of forms of insurance which maximize provider discretion over pricing and patterns of service" (p.98). The system that eventually evolved constituted a compromise for the various interest groups[4], with the major concession to physicians being the retention of fee-for-service as the mode of remuneration. While the provincial insurance plans negotiated the overall increases available to the profession for medical services, the provincial governments were unwilling to formally constrain physician pricing power[5]; the determination of fees for each specialty and procedure was left to the profession. Hence, the overall increase may be distributed differently from year to year and the utilization of procedures will show differential increases.

The source of cost increases became more important with the alteration of the financing arrangements[6] in 1977, together with the increasing claims from other public sector activities in competition with health care. Further, the world economy experienced a contraction following the oil crisis of the 1970's and the subsequent decline in economic growth rates made it more difficult to guarantee access to "highest quality care for all". Budget constraints on all forms of public spending emphasized the key economic concepts of scarcity of resources and the necessity to make choices in order to contain expenditures. The nature and consequences of the choices came under greater scrutiny. One possible source of cost increases was "unnecessary" surgery. Abel-Smith (1979) cites incentives whereby the fee-for-service payment system could distort the practice of medicine by favouring elective surgery, some of which is deemed unnecessary. It is suggested that the international differences in certain elective surgical rates are partly explained by the different payment systems.

The return to the physician will influence the nature and number of admissions and the type of operations. We note again that physician discretion is greatest in the case of elective procedures. If the choice of elective surgical procedures is supplier driven, it is to be expected that those elective surgical procedures that became relatively more expensive will exhibit greater increases or less marked decreases in utilization over the period under study. Economic behaviour in response to such incentives would be reflected in output responses. An output mix where the more expensive procedures predominated would contribute to higher costs[7].

Conditions for which elective surgical procedures are a possibility offer greater scope for discretion in terms of treatment, and it is suggested here that financial factors may account for at least some of the variations in elective surgery. The role of financial factors has attracted more attention given the urgency of controlling health care expenditures. A selective review of the literature supporting the influence of financial factors follows.

2.2 VARIATIONS IN ELECTIVE SURGICAL RATES

Economic incentives can be manifested in a number of ways. The existence of differential fees is a major reason to expect responses to financial influences, but other support for such responses is obtained from studies comparing practice patterns before and after the introduction to health insurance and from studies examining the influence of the effects of patient versus physician characteristics on surgical rates. Since the literature in the field is very extensive, a representative sample of studies supporting responses to economic incentives will be reviewed. In particular, fee-for-service reimbursement is shown to contain incentives to perform the more costly procedures in treating patients.

The impact of the fee structure on the use of physician time was investigated even before the introduction of medicare. Some early studies in the medical literature expressed concern that financial factors were playing too great a role in unnecessary surgery, as evidenced by support for socio-economic factors in explaining elective surgical rates. In two very early studies Groves (1908) and Codman (1914) (quoted in Rutkow and Zuidema, 1978) expressed concern about excessive surgery and cautioned against the tendency to operate where it was not clinically warranted[8]. For Canada, a representative view is that of Clute (1963), who expressed concern about a reward system that "... places an overwhelming emphasis on both minor and major procedural items, such as surgery and laboratory tests, and downgrades virtually all visit items" (p.118). He continued, ".... unless surgical procedures were very much more demanding on the skill of the physician than is non-surgical work, there should be no differential in the amount received for the time spent in the operating room and for the time spent on office hours, home calls and hospital rounds." (p.207).

Comparisons of surgical rates in different countries have shown that they did not correspond to differences in morbidity and disease incidence. Vayda (1973) compared age-standardized surgical rates between Canada, the United States, and England and Wales. The rates for men and for women for elective and non-elective procedures were found to be 1.8 and 1.6 times as high, respectively, in Canada than in England and Wales while the rates in the United States were twice those in England and Wales. When elective procedures were considered separately, the differences were even more marked[9]. Three major reasons were suggested for these international differences. Non-surgical treatment tended to be favoured in England and Wales; there were fewer surgeons per capita in England and Wales; and the delivery of the health services and the different insurance schemes incorporated different financial incentives. In his assessment of the causes of such differences, Vayda concludes that "...the way in which health care is organized and financed may be a major determinant of rates..." (p.1228). The greater tendency of Canadian physicians to use in-hospital facilities can be explained by the incentives inherent in the Canadian health system with the introduction of hospital insurance before medical insurance.

Variations in surgical rates were found to exist between Canadian provinces. Vayda, Morison and Anderson (1976) selected data on eight elective procedures and seven non-elective operations[10] for the years 1968-1972. While the rates of non-elective procedures exhibited little variation across provinces, differences in rates of more than 20 per cent were noted for three elective operations - hysterectomy, tonsillectomy and adenoidectomy, and cholecystectomy. It was considered unlikely that these differences were due to differences in the incidence of disease. Again, financial incentives were among the factors cited as possible explanations.

The widespread introduction of health insurance reduced and, in some jurisdictions, eliminated the patient's major financial barrier to surgery and directed more attention to the surgeon's role in the choice of elective surgery. Support for the role of financial factors was enhanced in comparisons of practice patterns before and after the introduction of universal medical insurance.

Vayda et al. (1976) found a positive correlation between the rate of elective surgical operations and changes in the extent of insurance coverage. In provinces where medical insurance had not been extensive, the rates for elective operations increased after the introduction of medicare. In Nova Scotia, New Brunswick and Quebec less than 75 per cent of the population was insured for surgical services in 1968. After the adoption of universal health insurance, the combined elective surgery rates rose by 25 per cent in Nova Scotia, 12 per cent in New Brunswick and 7 per cent in Quebec. There was little change where insurance coverage had been high[11].

The major provider characteristic pertaining to doctors is the type of practice. A consistent finding is that the fee-for-service mode reports higher surgical rates. For example, Hastings et al. (1970) found that patients served by the prepaid group health plan had lower surgical rates than those served by the fee-for-service physicians. This corresponds to results from an earlier study by Lewis (1969)[12]. Further indications of the payment method having an effect on costs and hospitalization rates are cited by Brown (1983).

A more recent study of above-average surgical rates in Alberta by Le Riche and Halliday (1983) also found higher elective surgical rates in fee-for-service practices. The rates for the Edmonton General Hospital were chosen as the standard for comparison in the evaluation of the varying surgical rates among the regions of Alberta in 1978. The independent variables were divided into three categories covering physician characteristics, patient characteristics and hospital characteristics. The most important finding regarding physician characteristics was that in high surgical rate areas more elective procedures were performed in fee-for-service practice. "For five of the seven elective procedures, the surgeons for high-rate regions worked under a fee-for-service arrangement more frequently than surgeons for low-rate regions. This occurred for only two of the seven non-elective procedures. This would seem to indicate that fee-for-service might influence the surgeons' decision-making for elective surgical procedures" (p.124).

2.3 SUMMARY

Despite budget restraints overall increases in health expenditures may still occur if the output mix changes to include more expensive procedures. The pricing of different procedures and benefits to the different specialty groupings has been left to the profession; only the overall increase in funding is negotiated by the respective provincial governments. The number of operations performed will depend on their benefit rates relative to other procedures as well as the price of the operation itself.

Variations in surgical rates have been the subject of investigation in numerous studies. International and intranational differences in elective surgery rates could not be explained by differences in disease incidence. There is support in the literature that over-servicing has been induced, at least in part, by financial incentives, especially with regard to elective surgery. A response to financial incentives whereby the service mix alters to emphasize more remunerative procedures can have major cost implications for the financing of health care.

Prior to modelling the economic response to financial incentives as incorporated in the fee structure, the extent of variations in price and quantity data in Canada in the period since the introduction of medicare when the majority of physicians have operated under the fee-for-service system is examined. Key variables relating to benefit rates, surgical rates and costs in the Canadian health care system are considered in Chapter Three.

NOTES TO CHAPTER TWO

1 An elective surgical procedure is defined as one that is not required to save the patient's life at the time of admission to hospital. In the case of elective procedures, there are alternatives to surgical treatment and clinicians are not in absolute agreement as to the correct mode of treatment. Some procedures would not be elective in all circumstances, but available data do not identify those instances where the operation is mandatory. However, studies on Manitoba surgical rates by Roos and colleagues indicate that the instances of mandatory surgery were low; 8 per cent of hysterectomies were for conditions considered urgent (Roos et al., 1983). Only 2 per cent of cholecystectomies were judged acute, that is, performed on the day of admission to hospital (Cageorge et al., 1981).

2 Canada's decision to provide universal hospital insurance arose from the desire to protect families from the possible financial catastrophe associated with serious illness and to alleviate the financial difficulties anticipated by hospitals. Experience with government sponsored programmes indicated that public insurance was less expensive to provide than private health insurance (See Brown, 1983, p.41).

3 The medical profession's opposition to public medical insurance in Canada is well-documented; for example, see Taylor (1978) and Brown (1983). Vayda (1977) notes the opposition to prepaid group practice.

4 See Taylor (1978) for a discussion of the negotiations with the medical associations in each of the provinces.

5 See Evans (1984), p.329 and Brown (1983), p.92.

6 The alteration to the financing arrangements are contained in the 1977 Federal Provincial Fiscal Arrangements and Established Programs Financing Act.

7 Roos et al. (1982) quotes estimates of cost implications from a United States study. If the high use strategy was followed across the United States, costs were estimated to be $6.8 billion, while a low use strategy was estimated to be $3.0 billion (1973 U.S. dollars).

8 In a later study, Glover (also quoted in Rutkow and Zuidema, 1978) found considerable variations in the 1938 tonsillectomy rates for English school children. The overall rates in different areas ranged from 40 to 440 operations per 10,000 children, and appeared to be related to socio-economic factors rather than disease incidence. For example, the rates were especially high among the children of well-to-do parents. Lewis (1969) suggested the importance of socio-economic factors in his study of tonsillectomy-adenoidectomy rates in England and Wales.

9 For example, the 1968 age-standardized cholecystectomy rate for males was 27 per 100,000 in Britain compared with 135 per 100,000 in Canada, and overall elective surgical rates in Canada were double those in England and Wales. Data did not support the hypothesis that there was an insufficient amount of surgery performed in England and Wales.

10 The eight elective operations constituted more than one-third of all primary surgical operations in each of the five years, while the non-elective operations constituted 5 per cent of all primary surgery.

11 While some of the changes indicate a response by physicians to the increased demand, numerous studies have confirmed fewer home visits and a shift to more remunerative procedures with the introduction of medicare. With regard to Manitoba surgical rates , the excess demand explanation was not supported. Rather, expansion of surgical workloads "...is often an option for the physician" (Roos, 1983, p.421).

12 Both studies were cited in Vayda (1973) as indications of the "direct incentive of financial remuneration" (p.1228). A later study by Wennberg and Gittelsohn (1982), confirmed the importance of provider characteristics. Their study of 193 hospital areas in the six New England states for various periods from 1969 to 1977 found that provider characteristics were more important than population characteristics in explaining differences in surgical rate variations once the patient was "in the system."

CHAPTER THREE

KEY VARIABLES IN THE CANADIAN HEALTH CARE SYSTEM

3.1 INTRODUCTION

While rising levels of health care expenditures had caused little concern in the 1950's and 1960's, subsequent changes in economic conditions have forced reappraisals of spending on health, and cost containment has become a major objective for health care systems, regardless of the extent of government involvement. The search for the means to contain the cost of health care has taken place in the wider context of the economic consequences of the increase in oil prices in the 1970's. As noted in Abel-Smith (1983), there has been a "crisis of financing" for health care.

The impact of the "crisis of financing" differed depending on the organization and financing of the health system as well as on the population characteristics, including the age structure of the population. While the trends in health expenditure can be attributed to a number of causes[1], economists are concerned with the role of departures from economic efficiency as reasons for rising costs.

In Canada, the passing of the 1977 Federal Provincial Fiscal Arrangements and Established Programmes Financing Act (EPF) resulted in the original open-ended nature of federal government financing being replaced by "formula funding", the results of which constrained federal funding for health care[2].

While comparisons of health care costs in Canada with those in other countries, and in particular with the United States, have shown that Canadian cost containment is relatively successful, concern remains that inefficiencies in providing health care are one reason for rising costs. One source of such inefficiency may be unnecessary surgery. As noted above for elective surgery in particular, the variations in rates internationally are above those expected on the basis of morbidity comparisons, suggesting that socio-economic factors may play a significant role. In Canada, the delivery of medical services remains in the hands of private practioners, who are paid on a fee-for-service basis. We consider below the interprovincial variations in elective surgical rates and the fees associated with them. The fee variation results from the financing arrangements in Canada.

Health care is in the area of provincial jurisdiction, albeit with extensive federal financial support for provincial health insurance plans, providing the plans meet the accessibility conditions (see LeClair, 1975) set down in the 1957 Federal Hospital Insurance and Diagnostic Services Act. While the provincial governments negotiate the overall increases in funding for medical services with the provincial medical associations, the allocation of increases to the different specialties and thus to the different fees is left to the profession. Variations in relative benefit rates have, therefore, occurred over time and among provinces.

Variations in benefit rates are presented and discussed in Sections 3.4, 3.5 and 3.6, following a review of total health care costs in Section 3.2 and of elective surgical procedures in Section 3.3. It is anticipated that providers will respond to prices in deciding on time allocation, and the possibility that "opted-out" prices are the relevant ones needs to be addressed; this matter is considered in Section 3.7. Section 3.8 concludes the review of data sources by looking at the number of hospital beds and of physicians.

3.2 TOTAL HEALTH CARE COSTS IN CANADA

Total health expenditures as a percentage of Gross National Product (GNP), for selected years, are reported in Table 3.1. The major categories are also shown as percentages of GNP. While expenditures on physician services decreased from 1.2 to 1.0 per cent of GNP, the percentage of expenditures on hospitals increased from 2.6 to 3.1 per cent. Thus, although health care costs relative to GNP rose during the 1950's and 1960's (from 5.6 per cent in 1960 to 6.9 per cent in 1968), they remained fairly stable throughout the 1970s.

Total expenditures and their percentage distribution by major category are tabulated in Table 3.2. Institutions have accounted for over half of the total expenditure. From 1978, the share accounted for by general and allied special hospitals remained stable at 40 per cent of total expenditures. The share of expenditures for physicians services declined from 17 per cent in the early 1970's, to about 14.5 per cent of the total in 1981. Decisions regarding the $10.4 billion spent of hospital expenditures in 1981 would have been made largely by physicians.

TABLE 3.1

TOTAL HEALTH EXPENDITURES AS A PERCENTAGE OF GROSS NATIONAL PRODUCT

MAJOR CATEGORIES, SELECTED YEARS, CANADA: 1973-1981

CATEGORY	1973	1978	1980	1981
General and Allied Special Hospitals	2.6	3.0	3.0	3.1
Homes for Special Care	.6	.9	.9	1.0
Physicians' Services	1.2	1.1	1.1	1.0
Dentists' Services	.3	.4	.4	.4
Drugs and Appliances	.8	.8	.8	.8
Other Expenditures	1.6	1.2	1.3	1.2
TOTAL (per cent of GNP)	7.1	7.4	7.5	7.5

Source: Canada, Health and Welfare Canada (1984).

TABLE 3.2

TOTAL HEALTH EXPENDITURES BY MAJOR CATEGORIES

AND PERCENTAGE DISTRIBUTION, SELECTED YEARS, CANADA: 1973-1981

CATEGORY	1973	1978	1980	1981
General and Allied Special Hospitals	3 235 (37.1)	6 929 (40.5)	8 920 (40.2)	10 365 (40.2)
Homes for Special Care	713 (8.2)	2 005 (11.7)	2 710 (12.2)	3 531 (13.7)
Physicians' Services	1 483 (17.0)	2 544 (14.9)	3 285 (14.8)	3 741 (14.5)
Dentists' Services	419 (4.8)	954 (4.9)	1 288 (5.8)	1 483 (5.8)
Drugs and Appliances	1 029 (11.8)	1 844 (10.8)	2 266 (10.2)	2 684 (10.4)
Capital Expenditures	457 (5.2)	766 (4.5)	1 220 (5.5)	1 332 (5.2)
Other Health Costs	1 384 (15.9)	2 052 (12.7)	2 490 (11.3)	2 633 (10.2)
TOTALS	8 720 (100.0)	17 094 (100.0)	22 179 (100.0)	25 769 (100.0)

Note: Figures in millions of dollars, with percentages in brackets.
Source: Canada, Health and Welfare Canada (1984).

Hence their share of total health expenditures underestimates the importance of the physician's role in resource allocation in the health care system.

Per capita spending on health, shown in Table 3.3 for selected years, increased from $395 per person in 1973, to $726 in 1978, and to $1058 in 1981. The category representing the major part of the expenditures, hospitals, recorded, on a per capita basis, $131, $294 and $425 for the same years. A breakdown of per capita health expenditures by province for 1981 is given in Table 3.4.

The percentages in Tables 3.1 through 3.4 do not highlight the cause for concern expressed about costs. Although cost remained a constant percentage of G.N.P., the financing method introduced by the federal government in 1977 placed the onus of cost control on the provincial health ministries. Expenditures are influenced by both prices and quantities. A comparison of health expenditures in current dollars with constant dollar figures indicates the importance of price effects, which is especially noticeable from the late 1970's. Health and Welfare Canada (1984) data show a 51 per cent increase in current dollar expenditures between 1978 and 1981, whereas the constant dollar figures indicate only an 18 per cent increase between 1978 and 1982.

The changes in service mix within the broad categories have raised questions with respect to costs effectiveness. In order to test for price response in the service mix, disaggregation of expenditures is necessary. Due to constraints on computer time and econometric difficulties associated with estimating large numbers of parameters, only four procedures were selected for estimating supply responses. Utilization

TABLE 3.3

TOTAL HEALTH EXPENDITURES PER CAPITA BY MAJOR CATEGORY, CANADA, 1973-1981

CATEGORY	1973	1974	1975	1976	1977	1978	1979	1980	1981
General and Allied Special Hospitals	131	147	219	251	273	294	323	371	425
Homes for Special Care	32	40	50	62	75	85	96	113	145
Physicians' Services	67	74	84	91	99	108	120	136	154
Dentists' Services	19	22	26	30	36	41	47	54	61
Drugs and Appliances	47	50	57	65	72	78	87	94	110
Capital Expenditures	21	25	27	28	29	33	35	51	55
Other Health Costs	78	100	82	88	83	87	94	102	108
TOTAL (per capita)	395	458	545	615	667	726	802	921	1058

Source: Canada, Health and Welfare Canada (1984).

TABLE 3.4

TOTAL HEALTH EXPENDITURES PER CAPITA BY PROVINCE AND MAJOR CATEGORY, 1981

CATEGORY	CANADA	NF	PE	NS	NB	QU	ON	MA	SA	AL	BC
General and Allied Special Hospitals	425	383	280	420	368	506	387	408	381	420	420
Homes for Special Care	145	119	169	135	172	140	157	195	153	132	109
Physicians' Services	154	93	110	132	98	130	173	137	128	157	197
Dentists' Services	61	22	41	42	32	44	70	60	57	62	95
Drugs and Appliances	110	164	119	157	131	86	111	107	149	101	130
Capital	55	38	122	30	68	38	36	54	40	144	89
Other Health Costs	108	90	118	116	79	88	107	135	107	141	118
TOTAL (per capita)	1058	909	959	1032	948	1032	1041	1096	1015	1157	1158

Source: Canada, Health and Welfare Canada (1984).

data for the four elective surgical procedures selected are discussed in Section 3.3.

3.3 ELECTIVE SURGICAL PROCEDURES

Data on the number of operations by type were obtained from Statistics Canada (various published and unpublished sources) and from a Health and Welfare Canada (1982) report. The initial choice of elective surgical procedures was drawn from those commonly considered by clinicians in their studies of surgical rate variations. In the end only four procedures were selected in order to test output responses. For the ten provinces of Canada, these four services represent on average 30 per cent of the value of benefits paid for procedures[3] in the major surgery category. The four[4] are haemorroidectomy(HM)[5], inguinal herniorraphy(IH)[6], cholecystectomy(CH)[7] and hysterectomy(HT)[8]. These procedures have been the focus of much attention in the medical literature. Lifestyle factors play a major role in the development of the underlying morbidity conditions for which surgical procedures are a treatment option; alternatives to surgery are available and the operation is usually elective[9].

The number of these four elective procedures by province appears in Table 3.5. The number of operations performed fluctuated over time, but the overall trend was one of decrease in all provinces, with the exception of Newfoundland. Table 3.6 reports the numbers for the four elective operations selected per thousand population by province; the percentage changes are similar to those in Table 3.5.

Despite the reduced surgical rates reported in Tables 3.5 and 3.6, payments to physicians have been increasing since 1973. Surgeons

TABLE 3.5

NUMBERS OF SELECTED SURGICAL PROCEDURES, BY PROVINCE, 1973-1981

	NF	PE	NS	NB	QU	ON	MA	SA	AL	BC	TOTAL
						HAEMORROIDECTOMY (HM)					
1973	194	101	634	694	7 215	7 618	862	860	1 707	2 423	22 308
1974	205	69	596	667	7 213	7 173	807	805	1 694	2 363	21 592
1975	227	96	606	680	6 768	7 121	705	729	1 542	2 267	20 741
1976	228	62	599	846	6 601	7 460	680	699	1 525	2 377	21 077
1977	267	64	572	691	5 856	6 344	637	674	1 409	2 405	18 919
1978	228	94	591	708	6 460	6 341	639	661	1 341	2 188	19 251
1979	283	88	572	673	6 198	6 171	631	687	1 388	2 197	18 888
1980	232	72	559	611	5 619	5 599	636	649	1 381	2 121	17 479
1981	277	65	594	566	6 406	5 545	574	583	1 284	2 012	17 906
						HERNIORRAPHY (IH)					
1973	705	322	1 813	1 590	16 005	23 412	2 629	1 911	4 236	6 276	58 899
1974	852	268	1 871	1 506	16 053	23 681	2 611	1 887	4 096	5 906	58 731
1975	866	336	1 938	1 478	15 892	24 434	2 684	1 849	3 943	6 120	59 540
1976	855	357	2 020	1 675	16 268	24 555	2 680	2 106	4 171	6 930	61 617
1977	950	291	1 888	1 650	15 221	22 821	2 555	1 921	3 914	6 690	57 901
1978	934	301	1 931	1 712	15 643	22 512	2 566	1 954	4 079	5 953	57 585
1979	907	313	1 862	1 694	15 532	22 848	2 480	1 804	4 076	6 091	57 607
1980	950	274	1 938	1 728	14 960	22 317	2 778	1 857	4 250	6 432	57 484
1981	984	316	1 915	1 621	15 884	22 660	2 448	1 915	4 311	6 605	58 659

TABLE 3.5 (CONTINUED)

	NF	PE	NS	NB	QU	ON	MA	SA	AL	BC	TOTAL
					CHOLECYSTECTOMY (CH)						
1973	1 009	465	3 061	2 584	31 604	28 316	4 197	2 994	7 415	8 117	89 762
1974	1 049	399	3 061	2 288	30 354	28 288	3 701	2 890	7 031	8 195	87 256
1975	1 023	436	2 718	2 133	26 797	26 729	3 450	2 588	6 140	7 577	79 591
1976	1 014	440	2 790	2 161	24 937	25 048	3 198	2 423	5 773	7 704	75 488
1977	1 083	356	2 487	2 041	21 617	21 700	2 997	2 170	5 234	6 949	66 634
1978	1 041	335	2 424	2 002	20 255	19 897	2 605	2 069	4 917	6 008	61 553
1979	1 163	264	2 181	1 755	18 398	18 997	2 572	1 867	4 713	5 804	57 714
1980	1 097	325	2 169	1 639	17 539	18 424	2 561	1 780	4 433	5 485	55 452
1981	1 081	343	2 182	1 642	17 657	18 231	2 297	1 753	4 438	5 608	55 232
					HYSTERECTOMY (HT)						
1973	1 063	339	3 446	2 078	21 273	23 012	2 398	2 437	6 542	7 234	69 822
1974	1 128	328	3 115	2 049	21 406	22 795	2 218	2 282	6 103	7 448	68 872
1975	1 244	356	2 845	2 036	20 337	24 307	2 278	1 702	5 942	7 903	68 950
1976	1 296	361	2 815	2 158	19 711	23 647	2 149	1 585	5 643	8 549	67 914
1977	1 442	387	2 868	2 152	18 462	21 832	2 152	1 556	5 429	8 059	64 339
1978	1 415	342	2 868	2 447	19 294	21 222	2 156	1 767	5 337	7 491	64 339
1979	1 429	336	2 732	2 324	19 026	21 159	2 054	1 755	5 377	7 487	63 679
1980	1 325	357	2 795	1 986	18 499	20 939	2 207	1 887	5 139	7 654	62 788
1981	1 518	396	2 544	2 077	19 880	20 470	1 867	1 833	5 026	7 330	62 941

Note: Data in Tables 3.5 and 3.6 are for the fiscal year ending March 31; they have been provided to the author by Health and Welfare Canada, based on definitions of the various procedures that are consistent both across jurisdictions and over time.

Source: Medical Care: Statistical Supplement to the Annual Report (unpublished) Canada, Health and Welfare Canada.

TABLE 3.6

RATES FOR SELECTED SURGICAL PROCEDURES, PER CAPITA BY PROVINCE 1973-1981

	NF	PE	NS	NB	QU	ON	MA	SA	AL	BC	CANADA
HAEMORROIDECTOMY (HM)											
1973	0.37	0.90	0.81	1.09	1.19	0.97	0.88	1.00	1.03	1.08	1.03
1974	0.38	0.61	0.75	1.04	1.19	0.91	0.81	0.94	1.00	1.02	0.98
1975	0.42	0.84	0.76	1.04	1.10	0.88	0.70	0.85	0.89	0.95	0.93
1976	0.41	0.53	0.74	1.27	1.07	0.91	0.67	0.81	0.85	0.98	0.93
1977	0.48	0.54	0.70	1.02	0.94	0.77	0.63	0.76	0.76	0.98	0.83
1978	0.40	0.78	0.72	1.03	1.03	0.76	0.62	0.74	0.70	0.88	0.83
1979	0.50	0.73	0.69	0.97	0.99	0.73	0.62	0.76	0.71	0.87	0.81
1980	0.40	0.59	0.67	0.88	0.90	0.66	0.62	0.71	0.68	0.82	0.74
1981	0.48	0.53	0.71	0.80	1.02	0.65	0.56	0.63	0.61	0.76	0.75
HERNIORRAPHY (IH)											
1973	1.33	2.88	2.32	2.50	2.65	3.00	2.67	2.21	2.55	2.79	2.72
1974	1.58	2.37	2.36	2.34	2.64	2.99	2.63	2.21	2.42	2.55	2.68
1975	1.60	2.92	2.42	2.26	2.59	3.03	2.68	2.16	2.28	2.56	2.68
1976	1.55	3.05	2.49	2.52	2.63	3.00	2.65	2.43	2.33	2.85	2.73
1977	1.70	2.47	2.30	2.44	2.44	2.77	2.51	2.18	2.12	2.72	2.53
1978	1.65	2.51	2.34	2.50	2.50	2.69	2.51	2.18	2.14	2.39	2.49
1979	1.59	2.58	2.24	2.45	2.48	2.71	2.42	2.00	2.07	2.41	2.47
1980	1.65	2.24	2.32	2.48	2.39	2.63	2.72	2.02	2.10	2.50	2.44
1981	1.69	2.57	2.28	2.30	2.52	2.65	2.39	2.06	2.05	2.49	2.46

TABLE 3.6 (CONTINUED)

	NF	PE	NS	NB	QU	ON	MA	SA	AL	BC	CANADA
						CHOLECYSTECTOMY (CH)					
1973	1.90	4.15	3.91	4.06	5.23	3.62	4.26	3.47	4.47	3.61	4.14
1974	1.95	3.53	3.87	3.56	4.99	3.57	3.73	3.38	4.16	3.54	3.98
1975	1.88	3.79	3.39	3.26	4.37	3.31	3.44	3.03	3.55	3.17	3.59
1976	1.84	3.76	3.44	3.25	4.03	3.06	3.17	2.79	3.23	3.17	3.35
1977	1.94	3.02	3.03	3.02	3.47	2.62	2.94	2.46	2.83	2.82	2.91
1978	1.84	2.79	2.94	2.92	3.24	2.38	2.55	2.31	2.58	2.41	2.66
1979	2.04	2.18	2.63	2.54	2.94	2.25	2.51	2.06	2.40	2.29	2.47
1980	1.91	2.66	2.60	2.35	2.80	2.17	2.50	1.94	2.19	2.13	2.36
1981	1.86	2.79	2.59	2.33	2.80	2.13	2.24	1.89	2.11	2.12	2.32
						HYSTERECTOMY (HT)					
1973	6.41	8.76	12.48	9.48	9.66	8.07	6.74	8.11	11.55	8.87	8.97
1974	6.64	8.26	11.03	9.11	9.53	7.80	6.13	7.56	10.45	8.78	8.63
1975	7.19	8.68	9.83	8.79	8.89	8.09	6.18	5.56	9.81	8.94	8.47
1976	7.30	8.51	9.51	9.06	8.39	7.69	5.74	5.03	8.91	9.38	8.10
1977	7.88	9.04	9.49	8.84	7.71	6.91	5.62	4.85	8.17	8.56	7.48
1978	7.67	7.84	9.43	9.94	8.02	6.62	5.59	5.43	7.77	7.85	7.36
1979	7.47	7.52	8.70	9.11	7.76	6.43	5.23	5.24	7.45	7.57	7.09
1980	6.77	7.83	8.75	7.63	7.45	6.26	5.58	5.52	6.86	7.54	6.85
1981	7.57	8.57	7.83	7.83	7.93	6.02	4.68	5.26	6.42	6.98	6.75

Note: Rates are per 1 000 population and for HT, per 1 000 female population over 15.

Source: See Table 3.5.

are paid more to perform cholecystectomies and hysterectomies than to perform haemorroidectomies or herniorraphies; it is possible that the budget restraints imposed by the provincial governments at the global level have provided incentives for surgeons to increase the amount of time they devote to these higher priced services. Although the data presented in Section 3.3 show a decline in the number of operations performed over the period, health expenditures have been rising, suggesting the strength of the price effect over the quantity effect in total health costs. Comparisons of benefit rates and the extent of price variation is taken up in Sections 3.3 and 3.4 respectively.

3.4 PRICES: BENEFIT RATES

The prices of each of the four elective procedures, as used in the study, are the adjusted provincial benefit rates. Indexed benefit rates for the years 1973 to 1981, based on unpublished data made available by Health and Welfare Canada, Health Information Division, are provided in Table 3.7. While prices had remained stable throughout the early 1970s, marked increases were experienced after 1977 in all four operations being considered. (The construction of the index for "Other Procedures" is discussed in the next section.)

Each of the four operations recorded differing rate increases in each province. For example, the index of haemorroidectomies rose to 165.4 in Newfoundland (NF) but to 229.6 in British Columbia (BC). Comparing the indexes for inguinal herniorraphy, the index rose to 161.1 for Newfoundland, but to 300.5 for British Columbia. New Brunswick (NB)

TABLE 3.7

INDEXES OF BENEFIT RATES, BY PROVINCE, 1973-81

A. HAEMORROIDECTOMY

	1973	1974	1975	1976	1977	1978	1979	1980	1981
NF	100.0	100.0	100.0	108.6	121.0	123.5	123.5	123.5	165.4
PE	100.0	115.9	117.8	125.0	129.6	134.8	143.9	153.2	166.3
NS	100.0	109.2	118.4	128.8	139.0	144.9	149.9	154.8	182.1
NB	100.0	103.6	107.2	102.4	113.5	116.9	121.1	122.4	149.7
QU	100.0	100.0	100.0	100.0	100.0	111.5	130.3	135.3	144.7
ON	100.0	108.9	117.8	121.7	126.4	127.8	132.1	143.3	154.4
MA	100.0	110.5	118.1	124.3	136.2	144.9	154.4	165.1	210.2
SA	100.0	100.0	100.0	111.8	136.8	157.4	205.9	220.6	256.9
AL	100.0	104.2	108.4	109.4	117.5	120.2	138.6	147.4	164.9
BC	100.0	108.6	117.9	133.3	145.4	151.6	160.7	163.3	229.6

B. INGUINAL HERNIORRAPHY

NF	100.0	100.0	100.0	108.9	120.0	122.2	122.2	122.2	161.1
PE	100.0	115.6	117.5	124.7	129.2	134.5	143.6	152.8	165.9
NS	100.0	109.2	118.4	128.8	139.1	144.9	149.4	159.6	177.2
NB	100.0	103.6	107.2	105.4	113.5	116.4	129.5	133.8	222.5
QU	100.0	100.0	100.0	100.0	100.0	111.3	126.3	130.0	145.0
ON	100.0	109.0	118.3	124.1	128.7	129.9	139.2	151.1	162.6
MA	100.0	106.7	112.8	118.2	129.4	138.1	147.1	157.1	196.3
SA	100.0	100.0	100.0	111.1	114.8	124.0	127.1	137.6	189.2
AL	100.0	104.4	108.5	109.6	118.2	127.3	129.3	142.8	163.9
BC	100.0	127.5	160.0	187.2	204.0	212.7	226.5	230.5	300.5

TABLE 3.7 (CONTINUED)

C. CHOLECYSTECTOMY

	1973	1974	1975	1976	1977	1978	1979	1980	1981
NF	100.0	100.4	100.5	108.9	122.0	125.4	123.4	122.7	150.7
PE	100.0	115.9	117.8	125.0	129.6	134.8	143.9	153.2	166.3
NS	100.0	109.2	118.4	128.8	139.2	144.9	149.4	154.8	182.1
NB	100.0	103.6	107.2	102.4	113.8	116.9	121.1	122.4	149.7
QU	100.0	100.0	100.0	100.0	100.0	113.2	139.7	147.1	158.1
ON	100.0	107.4	116.2	122.6	127.9	134.9	143.0	155.7	163.1
MA	100.0	106.4	112.7	118.6	146.1	161.2	150.7	154.0	181.9
SA	100.0	124.0	152.4	167.6	170.2	170.2	174.8	176.3	208.2
AL	100.0	104.2	108.4	109.5	118.3	127.8	135.1	139.4	155.8
BC	100.0	109.4	118.8	135.4	147.5	153.8	163.6	166.4	202.4

D. HYSTERECTOMY

NF	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	127.9
PE	100.0	109.2	118.4	125.6	130.2	135.5	144.6	153.9	167.2
NS	100.0	109.2	118.4	135.1	140.0	151.5	158.9	164.5	178.5
NB	100.0	102.7	107.2	105.4	113.5	116.5	120.6	122.8	147.3
QU	100.0	100.0	100.0	100.0	100.0	108.8	111.8	111.8	111.8
ON	100.0	100.0	100.0	100.0	105.6	109.4	115.0	120.8	129.9
MA	100.0	106.5	113.1	119.2	130.4	139.1	148.0	158.0	185.7
SA	100.0	100.0	100.0	100.0	93.9	92.1	96.3	100.9	134.1
AL	100.0	104.2	108.5	109.5	109.5	109.3	111.0	111.6	112.5
BC	100.0	108.6	107.9	123.1	134.0	139.6	148.9	150.8	181.9

Note: The data were adjusted to reflect prices as of October 1 of each year; the indexes are based on unpublished fee schedule comparisons, as complied by Health and Welfare Canada to ensure consistency across jurisdictions and over time.
(1973 = 100 for each province)

reported a rise of 122.5 percentage points in the index for inguinal herniorraphies, but smaller increases for the other three operations. Saskatchewan (SA) reported higher than average index changes for all procedures except hysterectomy. With respect to cholecystectomies, Newfoundland and New Brunswick reported the lowest changes in the price index over the period, rising to 150.7 and 149.7 respectively. The indexes for the other provinces ranged from 158.1 for Quebec (QU) to 208.2 for Saskatchewan.

The indexes for the benefit rates indicate differences from year to year within each province. Our concern is whether these differences are associated with changes in output mix, within the four procedures selected and also among the four procedures and all other procedures.

3.5 PRICE INDEX FOR OTHER PROCEDURES

Since surgeons perform other procedures as well as the four on which we focus, a further price index was constructed to account for all other procedures, including the remaining major surgical procedures. Initially, an index for all other major surgical procedures was constructed. The indexes, based on confidential data supplied by Health and Welfare Canada, were province-specific, with the weights based on service experience in 1981. The weight for the i^{th} procedure in the j^{th} province (W_{ij}) is equal to the number of each major surgical procedure performed, excluding the four operations selected, divided by the total number of other major surgical procedures, excluding the four operations selected. Each W_{ij} is positive and the sum of the W_{ij}'s for each j is unity.

TABLE 3.8

OTHER SERVICES PRICE INDEX, BY PROVINCE, 1973-81

	1973	1974	1975	1976	1977	1978	1979	1980	1981
NF	100.0	115.0	132.4	143.4	145.7	165.9	165.9	217.8	241.9
PE	100.0	110.8	113.7	118.7	124.7	148.4	159.9	176.6	193.3
NS	100.0	108.8	118.0	131.7	135.7	154.6	167.0	191.9	214.0
NB	100.0	103.5	109.5	122.0	131.0	136.7	142.7	174.5	199.0
QU	100.0	100.9	99.0	99.0	124.0	132.0	132.0	141.5	141.6
ON	100.0	107.8	110.2	118.6	125.0	129.8	137.8	148.1	174.8
MA	100.0	106.6	112.1	123.0	134.3	141.2	154.9	178.4	205.6
SA	100.0	114.1	117.5	127.7	136.5	144.7	156.6	190.1	221.3
AL	100.0	103.9	110.6	118.0	126.9	133.7	140.9	175.5	202.2
BC	100.0	108.6	122.9	132.1	134.0	153.0	152.6	183.7	227.5

Note: Derivation described in Section 3.5 of text; this index is based on unpublished fee schedule comparisons, as compiled by Health and Welfare Canada to ensure consistency across jurisdictions and over time.

These weights are applied to the corresponding benefit rates (B_{ijt}). The resulting values are summed to obtain a price index for other major surgical procedures, by province (P_{ojt}), denoted by 3.1.

$$P_{ojt} = \sum_{i} W_{ij} \; B_{ijt} \qquad (3.1)$$

The average rates for office visits and other surgical and diagnostic procedures for all specialities are added to the price index represented by equation (3.1) to arrive at the overall index for all other procedures.

Table 3.8 contains the derived indexes of benefit rates for each province. Again, varying rates of increase are noticeable. Considering the extremes, in British Columbia, for example, the index was 227.5 in 1981, compared to a base of 100 in 1973. In contrast, it was only 141.6 in Quebec in 1981. After decreasing to 1976, the index for Quebec increased by 42.6 percentage points from 1976 to 1981. The corresponding change for British Columbia was an increase of 95.4. For the period 1979 to 1981, Newfoundland and Manitoba, for example, recorded changes of 76.0 and 50.7 percentage points respectively. The change in the latter period for British Columbia was 74.9 percentage points. In contrast, from 1976 to 1979, Ontario recorded an increase in the index of other procedures of 19.2 while the change in the index from 1979 to 1981 was 37.0.

3.6 PRICE VARIATION

The indexes of the benefit rates show differential rates of increase for the same procedure across provinces and also variations of the benefit rates for different procedures within each province. A measure of the variation was calculated by taking the ratio of the standard deviation to the mean of relative prices; the results are reported for Canada in Table 3.9 and by province in Table 3.10.

The ratio used to indicate variation is the coefficient of variation, and it is expressed as a percentage. With the numerator being the standard deviation, the coefficient of variation is an indicator of variation in a variable. The standard deviation provides a measure of dispersion around the mean and the coefficient of variation is made scale-free by dividing by the mean. While not a perfect measure of variation, especially if the data are non-normally distributed, the measure can suggest sufficient price variation for their effects on physician output to be considered further.

The yearly variations for Canada as a whole can be compared by reading down the columns of Table 3.9. For example, the variation in the relative price P_{IH}/P_{HM} in the first column of Table 3.9 ranged from 12.30 per cent in 1973 to 21.32 per cent in 1981, with fluctuations down to 9.20 per cent in 1977. Column 6 records the variation in the relative price P_{HT}/P_{IH} from 9.11 in 1978 to 15.04 in 1981. Coefficients of variation show similar ranges in mean relative prices over the period. The extent of relative price variation (for Canada) in any given year can be seen by comparing across the rows of Table 3.9. In 1973, for example, one standard deviation in P_{CH}/P_{IH} represented 15.35

TABLE 3.9

RELATIVE PRICES OF SELECTED SURGICAL PROCEDURES, CANADA, 1973-1981

	$\frac{P_{IH}}{P_{HM}}$	$\frac{P_{CH}}{P_{HM}}$	$\frac{P_{HT}}{P_{HM}}$	$\frac{P_{O}}{P_{HM}}$	$\frac{P_{CH}}{P_{IH}}$	$\frac{P_{HT}}{P_{IH}}$	$\frac{P_{O}}{P_{IH}}$	$\frac{P_{HT}}{P_{CH}}$	$\frac{P_{O}}{P_{CH}}$	$\frac{P_{O}}{P_{HT}}$
Mean-1973	1.269	2.192	2.267	.401	1.753	1.802	.320	1.802	.184	.179
S.D.	.156	.169	.266	.047	.269	.234	.052	.234	.022	.030
C.V.	12.30	7.70	11.73	11.72	15.35	12.99	16.25	12.99	11.96	16.76
Mean-1974	1.283	2.221	2.226	.408	1.741	1.743	.319	1.002	.184	.185
S.D.	.138	.195	.285	.044	.164	.202	.031	.075	.019	.026
C.V.	10.76	8.78	12.80	10.78	9.42	11.59	9.72	7.49	10.33	14.05
Mean-1975	1.302	2.292	2.207	.416	1.761	1.703	.320	.965	.183	.190
S.D	.143	.319	.298	.051	.140	.206	.033	.069	.019	.027
C.V.	10.98	13.92	13.50	12.26	7.95	12.10	10.31	7.15	10.38	14.21
Mean-1976	1.311	2.300	2.170	.424	1.756	1.666	.325	.949	.186	.197
S.D.	.148	.304	.247	.043	.136	.190	.028	.081	.018	.024
C.V.	11.29	13.22	11.38	10.14	7.75	11.41	8.62	8.54	9.68	12.18
Mean-1977	1.282	2.269	2.061	.419	1.779	1.615	.328	.910	.186	.204
S.D.	.118	.165	.187	.041	.149	.153	.036	.076	.026	.025
C.V.	9.20	7.27	9.07	9.79	8.38	9.47	10.98	8.35	13.98	12.25

TABLE 3.9 (CONTINUED)

	P_{IH}/P_{HM}	P_{CH}/P_{HM}	P_{HT}/P_{HM}	P_O/P_{HM}	P_{CH}/P_{IH}	P_{HT}/P_{IH}	P_O/P_{IH}	P_{HT}/P_{CH}	P_O/P_{CH}	P_O/P_{HT}
Mean-1978	1.279	2.301	2.030	.435	1.808	1.591	.341	.885	.190	.216
S.D.	.122	.166	.221	.054	.166	.145	.040	.095	.030	.027
C.V.	9.54	7.21	10.89	12.41	9.18	9.11	11.73	10.73	15.79	12.50
Mean-1979	1.248	2.223	1.952	.421	1.791	1.568	.338	.877	.189	.217
S.D.	.169	.236	.279	.067	.129	.153	.037	.081	.020	.026
C.V.	13.54	10.62	14.29	15.91	7.20	9.76	10.95	9.24	10.58	11.98
Mean-1980	1.261	2.193	1.926	.474	1.747	1.530	.377	.879	.216	.248
S.D.	.175	.265	.288	.088	.134	.148	.059	.098	.028	.038
C.V.	13.88	12.08	14.95	18.57	7.67	9.67	15.65	11.15	12.96	15.32
Mean-1981	1.318	2.138	1.837	.450	1.649	1.423	.347	.866	.211	.245
S.D.	.281	.281	.226	.073	.216	.214	.056	.105	.020	.025
C.V.	21.32	13.14	12.30	16.22	13.10	15.04	16.14	12.12	9.48	10.20

Source: Computed from confidential data supplied by Health Information Division, Health and Welfare, Canada.

Key: P_j refers to benefit rates for the four procedures discussed in Section 3.3 and P_O refers to index for other procedures (construction is explained in the text).
S.D. refers to the Standard Deviation of relative prices.
C.V. refers to the Coefficient of Variation = (S.D. x 100)/ Mean.

per cent of the mean, compared to 7.70 per cent for P_{CH}/P_{HM}. The coefficient of variation for P_{IH}/P_{HM} was 10.76 per cent in 1974, but was 21.32 per cent in 1981. The coefficient of variation for P_{HT}/P_{CH} varied from a low of 7.15 per cent (1975) to 12.12 per cent in 1981.

The variations across relative prices within provinces are indicated by the rows in Table 3.10, and the variations over the period across provinces for a given price ratio are indicated by reading down the columns of Table 3.10. The ratios with P_O show the widest variation in most provinces. For example, the coefficient of variation for P_O/P_{HT} varies from 22.62 per cent in Alberta (AL), 11.26 per cent in Quebec to a low of 4.57 per cent in Manitoba (MA). For P_{IH}/P_{HM} (column 1), the ratio varied from 0.91 per cent in Newfoundland to 14.74 in New Brunswick, and 10.80 in British Columbia to 19.18 in Saskatchewan.

One disadvantage with the coefficient of variation as a measure of price variation is that it can show variation where none exists. Table 3.11 records the ratios of the price indexes of the four procedures (Table 3.7) relative to the weighted price index of other procedures (Table 3.8). Despite the relatively small variation in the means of relative prices recorded in Table 3.11, an analysis of the means and their corresponding coefficients of variation reported in Tables 3.9 and 3.10 indicate that this disadvantage did not apply to this data set. In fact, taking extreme examples, the opposite occurs for New Brunswick and Nova Scotia. For New Brunswick, a given relative price may show little variation in terms of the indexes in Table 3.11, but variation is indicated in Table 3.10; for example, with P_{IH}/P_{HM} showing a coefficient of variation of 14.74 per cent and P_{HT}/P_{IH} a

TABLE 3.10

RELATIVE PRICE VARIATION OF THE SELECTED SURGICAL PROCEDURES, BY PROVINCE, 1973-1981

	$\frac{P_{IH}}{P_{HM}}$	$\frac{P_{CH}}{P_{HM}}$	$\frac{P_{HT}}{P_{HM}}$	$\frac{P_{O}}{P_{HM}}$	$\frac{P_{CH}}{P_{IH}}$	$\frac{P_{HT}}{P_{IH}}$	$\frac{P_{O}}{P_{IH}}$	$\frac{P_{HT}}{P_{CH}}$	$\frac{P_{O}}{P_{CH}}$	$\frac{P_{O}}{P_{HT}}$
Mean-NF	1.104	2.207	1.963	.436	2.000	1.778	.395	.889	.198	.226
S.D	.010	.070	.213	.070	.052	.180	.065	.088	.035	.054
C.V.	0.91	3.17	10.85	16.06	2.60	10.12	16.55	9.90	17.68	23.89
Mean-PE	1.389	2.246	2.206	.487	1.617	1.588	.350	.983	.217	.221
S.D.	.001	.082	.046	.042	.059	.033	.030	.025	.016	.018
C.V.	0.07	3.65	2.09	8.64	3.65	2.08	8.57	2.54	7.37	8.14
Mean-NS	1.333	2.284	2.136	.487	1.714	1.602	.363	.936	.212	.227
S.D.	.019	.056	.065	.042	.063	.039	.031	.044	.017	.018
C.V.	1.43	2.45	3.04	8.62	3.68	2.43	8.54	4.70	8.02	7.93
Mean-NB	1.493	2.382	2.027	.461	1.614	1.379	.311	.853	.193	.228
S.D.	.220	.103	.025	.058	.144	.162	.035	.038	.018	.029
C.V.	14.74	4.32	1.23	12.58	8.92	11.75	11.25	4.45	9.33	12.72
Mean-QU	1.167	2.059	1.874	.414	1.765	1.604	.355	.914	.201	.222
S.D.	.018	.083	.183	.038	.093	.144	.032	.122	.022	.025
C.V.	1.54	4.03	9.77	9.18	5.27	8.98	9.01	13.35	10.95	11.26

TABLE 3.10 (CONTINUED)

	$\frac{P_{IH}}{P_{HM}}$	$\frac{P_{CH}}{P_{HM}}$	$\frac{P_{HT}}{P_{HM}}$	$\frac{P_{o}}{P_{HM}}$	$\frac{P_{CH}}{P_{IH}}$	$\frac{P_{HT}}{P_{IH}}$	$\frac{P_{o}}{P_{IH}}$	$\frac{P_{HT}}{P_{CH}}$	$\frac{P_{o}}{P_{CH}}$	$\frac{P_{o}}{P_{HT}}$
Mean-ON	1.227	2.089	1.935	.388	1.702	1.578	.316	.928	.186	.201
S.D.	.028	.081	.124	.021	.036	.124	.013	.080	.007	.017
C.V.	2.28	3.88	6.41	5.41	2.12	7.86	4.11	8.62	3.76	-8.46
Mean-MA	1.146	2.014	2.048	.357	1.757	1.787	.312	1.021	.178	.175
S.D.	.030	.154	.075	.014	.129	.036	.013	.061	.016	.008
C.V.	2.62	7.65	3.66	3.92	7.34	2.01	4.17	5.97	8.99	4.57
Mean-SA	1.319	2.236	2.067	.395	1.692	1.532	.303	.924	.181	.203
S.D.	.253	.560	.670	.059	.234	.225	.025	.215	.024	.041
C.V.	19.18	25.04	32.41	14.94	13.83	14.69	8.25	23.27	13.33	20.20
Mean-AL	1.289	2.448	2.386	.389	1.899	1.849	.302	.973	.159	.168
S.D.	.043	.088	.326	.030	.048	.235	.025	.115	.016	.038
C.V.	3.34	3.59	13.66	7.71	2.53	12.71	8.28	11.82	10.06	22.62
Mean-BC	1.370	2.363	2.115	.464	1.743	1.569	.343	.895	.197	.220
S.D.	.148	.110	.138	.027	.205	.281	.047	.049	.014	.019
C.V.	10.80	4.66	6.52	5.82	11.76	17.91	13.70	5.47	7.11	8.64

Source: Computed from confidential data supplied by Health Information Division, Health and Welfare, Canada.

Key: P_j refers to benefit rates for the four procedures discussed in Section 3.3 and P_o refers to index for other procedures (construction is explained in the text).
S.D. refers to the Standard Deviation of relative prices.
C.V. refers to the Coefficient of Variation = (S.D. x 100)/ Mean.

value of 11.75 per cent. Although, from Table 3.11 relative prices with respect to P_O in Nova Scotia show no variation until 1976, from Table 3.10, there is variation with respect to the ratios of other relative price indexes. For example, P_{HT}/P_{CH} varies by 4.70 per cent; P_O/P_{HM} varies by 8.62 per cent.

While the ratios of price indexes, P_i/P_O, in Table 3.11 show some variation, especially in the more recent years of the study, there appears to be considerable variation in prices both over time and across provinces when relative prices within the four procedures are considered as in Tables 3.9 and 3.10. It is hypothesized that such variations will result in changes in the output mix of these procedures, and thus will be reflected in the differential use of hospital faciliti-es, which, in turn, will affect costs. Elective surgical procedures in particular are the focus of the study due to the wider variations in their rates that are not explained by pathological variations in diseases for which the procedures are a treatment option.

3.7 THE ROLE OF OPTING OUT

The relative prices used in the study are derived from the benefit rates paid by the provincial health insurance plans. The possibility that physicians are not responding to the provincial benefit rates, but instead to higher prices available to those who have opted out of the provincial health plan needs to be considered. For the opted-out price to be effective, not only must a significant number of doctors in each province opt out and bill at rates significantly above the medicare benefit rate, but also the extent of private billing must represent a

TABLE 3.11

INDEXES OF RELATIVE PRICES BY PROVINCE: 1973 - 1981

	1973	1974	1975	1976	1977	1978	1979	1980	1981
Newfoundland									
P_{HM}/P_O	1.00	.87	.76	.76	.83	.74	.74	.57	.68
P_{IH}/P_O	1.00	.87	.76	.76	.82	.74	.74	.56	.67
P_{CH}/P_O	1.00	.87	.76	.76	.84	.76	.74	.56	.62
P_{HT}/P_O	1.00	.87	.76	.70	.69	.60	.60	.46	.53
P.E.I.									
P_{HM}/P_O	1.00	1.05	1.04	1.05	1.04	.91	.90	.87	.86
P_{IH}/P_O	1.00	1.04	1.03	1.05	1.04	.91	.96	.87	.86
P_{CH}/P_O	1.00	1.05	1.04	1.05	1.04	.91	.90	.87	.86
P_{HT}/P_O	1.00	.99	1.04	1.06	1.04	.91	.90	.87	.86
Nova Scotia									
P_{HM}/P_O	1.00	1.00	1.00	.98	1.02	.94	.90	.81	.85
P_{IH}/P_O	1.00	1.00	1.00	.98	1.02	.94	.90	.83	.83
P_{CH}/P_O	1.00	1.00	1.00	.98	1.02	.94	.90	.81	.85
P_{HT}/P_O	1.00	1.00	1.00	1.03	1.03	.98	.95	.86	.83
New Brunswick									
P_{HM}/P_O	1.00	1.00	.98	.84	.87	.86	.85	.70	.75
P_{IH}/P_O	1.00	1.00	.98	.86	.87	.85	.91	.77	1.12
P_{CH}/P_O	1.00	1.00	.98	.86	.87	.86	.85	.70	.74
P_{HT}/P_O	1.00	.99	.98	.86	.87	.85	.85	.70	.74

TABLE 3.11 (CONTINUED)

	1973	1974	1975	1976	1977	1978	1979	1980	1981
Ontario									
P_{HM}/P_o	1.00	.93	.91	.84	.80	.86	.95	.91	.83
P_{IH}/P_o	1.00	.93	.91	.84	.80	.86	.92	.88	.83
P_{CH}/P_o	1.00	.93	.91	.84	.80	.86	1.01	.99	.90
P_{HT}/P_o	1.00	.93	.91	.84	.80	.84	.81	.75	.64
Quebec									
P_{HM}/P_o	1.00	1.01	1.07	1.03	1.01	.98	.96	.97	.88
P_{IH}/P_o	1.00	1.01	1.07	1.05	1.03	1.00	1.01	1.06	1.12
P_{CH}/P_o	1.00	1.00	1.05	1.03	1.02	1.04	1.04	1.05	.93
P_{HT}/P_o	1.00	.93	.91	.84	.84	.84	.83	.82	.74
Manitoba									
P_{HM}/P_o	1.00	1.04	1.05	1.01	1.01	1.03	1.00	.93	1.02
P_{IH}/P_o	1.00	1.00	1.01	.96	.96	.98	.95	.88	.95
P_{CH}/P_o	1.00	1.00	1.01	.96	1.09	1.14	.97	.86	.88
P_{HT}/P_o	1.00	1.00	1.01	.97	.97	.99	.96	.89	.90
Saskatchewan									
P_{HM}/P_o	1.00	.88	.85	.88	1.00	1.09	1.31	1.16	1.16
P_{IH}/P_o	1.00	.88	.85	.87	.84	.86	.82	.72	.85
P_{CH}/P_o	1.00	1.09	1.30	1.31	1.25	1.18	1.12	.93	.94
P_{HT}/P_o	1.00	.88	.85	.78	.69	.64	.61	.53	.61

TABLE 3.11 (CONTINUED)

	1973	1974	1975	1976	1977	1978	1979	1980	1981
Alberta									
P_{HM}/P_O	1.00	1.00	.98	.93	.93	.90	.98	.84	.82
P_{IH}/P_O	1.00	1.00	.98	.93	.93	.95	.92	.83	.81
P_{CH}/P_O	1.00	1.00	.98	.93	.93	.96	.96	.79	.77
P_{HT}/P_O	1.00	1.00	.98	.93	.86	.82	.79	.64	.56
British Columbia									
P_{HM}/P_O	1.00	1.00	.96	1.01	1.09	.99	1.05	.89	1.01
P_{IH}/P_O	1.00	1.17	1.30	1.42	1.52	1.39	1.48	1.25	1.32
P_{CH}/P_O	1.00	1.01	.97	1.02	1.10	1.01	1.07	.91	.89
P_{HT}/P_O	1.00	1.00	.88	.93	1.00	.91	.98	.82	.80

Note: Based on indices listed in Table 3.7 and Table 3.8.

large percentage of medicare payments. Although the percentage of doctors who bill patients outside the plan may raise concern in some provinces, the dollar values involved are relatively small. The maximum percentage of private billing in terms of total medical payments was 4.8 per cent for Alberta, followed by 3.5 per cent for Nova Scotia and Ontario. All other provinces reported lower percentages[10].

Regarding service-specific opting-out rates, Brown and Hicks (1983) have provided evidence that the opportunity for opting out and billing above tariff varies for different procedures. Over-billing was found to be below average for hospital-based services (including surgery). For the "major surgery" category, which incorporates the four operations selected, specialists' billing above the provincial medicare tariff represented only 2.7 per cent of the payments made by the medicare plan[11].

The results of the Brown and Hicks study are consistent with studies of opting-out patterns in other provinces. Although the surgery category is not subdivided to indicate opting-out rates for the four procedures selected, the conclusions are consistent with the hypothesis that over-billing is likely to be lower for surgical procedures, since office visits, eye examinations and confinements were the services most frequently subjected to "opting-out".

Since surgical procedures appeared to have offered less scope for extra-billing, we would expect that the use of opted-out (relative) prices would not materially affect the results obtained with "opted-in" relative prices. Further, the low ratio of private billings to total medicare payments suggests that the use of opted-out prices would have little effect on the estimates of supply responses. (The difficulty of obtaining suitable overall price ratios that include the opted-out component precludes more definitive study with regard to the effect of opted-out prices.)

3.8 THE SUPPLY OF PHYSICIANS AND HOSPITAL BEDS

PHYSICIANS

Data relating to the supply of active civilian physicians, distinguishing between general practice and specialties, are contained in Appendix I of this chapter. Only active physicians were included. Since this study investigates how physicians allocate time across specific professional activities, the physician variable should be defined as physician hours. Although family physicians may have been trained to perform some surgery in the past, current practice is that most operations are performed by surgical specialists. Hence, data were collected for "surgical specialists" rather than "total physicians"[12]. A study by Roos (1983) found little variation in surgical hours in Manitoba, and this is expected to apply to other provinces as well. Due to the length of time to train a surgical specialist, it was felt appropriate to treat surgical specialists as a key fixed factor in specifying the model.

HOSPITAL BEDS

Hospital beds represent an important part of the capital equipment available to surgical specialists in the treatment of their patients. Ideally, only surgical beds should be considered in a study of elective procedures, but data for surgical beds separately are available for only four of the nine years of the study. The hospitals covered are general and allied special hospitals; both public and private hospitals are included in this category.

Until 1976 statistics for hospital beds related to December 31. Since that time the data have been for a March 31 year end. Data for each province are included in Table 3.2A. All figures presented have been adjusted to relate to a date of October 1 of each year. (Since the output measures, the number of operations performed, were recorded for the year ending March 31, data for 1976, for example, report hospital beds on 1 October 1975 and total operations performed from 1 April 1975 to 31 March 1976. Quarterly series for hospital beds are not available and it was not considered appropriate to make further arbitrary adjustments to the data set.)

Until 1979 hospital beds were recorded on the basis of "beds set-up" for in-patient use. After that date beds were reported on the basis of "approved bed complement," indicating the number of beds approved by the provincial authorities. (Such approval is based on standards established in terms of floor area per bed.[13])

The decreases noted in the table are partly due to a change in classification, but due also to attempts to cut costs by reducing the supply of available beds through attrition or the amalgamation of services. LeClair (1975) notes that "this is being accomplished by closing small hospitals, by removing beds from service in larger hospitals, or redesignating formerly acute care beds for alternative care needs." The reduction in hospital beds is in accord with the recommendations of the Castonguay Report and the Hastings Report[14], which emphasized the benefits of shifting to ambulatory treatment where appropriate, to reduce the use of expensive acute care hospital beds. The planning guidelines for hospital facilities vary depending on conditions within each province, but the average is 4.0 beds per thousand population.

3.9 SUMMARY

The increasing cost of public sector activities has received much attention, prompted by the general slowing of economic growth following the reduction in macroeconomic activity since the 1970's. Regardless of the private-public mix in the health care system, the concern with rising costs in this area has prompted evaluation of the expenditures on health care and the causes of inefficiencies that may contribute to such rising costs.

Utilization data are consistent with the hypothesis that the number of physicians practising in the health system and their mode of remuneration will have a substantial impact on costs. The fee-for-service mode of remuneration, as discussed in Chapter Two, provides an incentive for the service mix to respond to differential fees. The coefficients of variation discussed in this chapter have indicated sufficient variation in the relative benefit rates to expect changes in the output mix to appear.

While the emphasis in this chapter has been on price data relevant to the analysis that follows, information relating to the numbers and distribution of physicians in Canada, as well as to the availability of hospital beds are presented and discussed also. Surgical procedures cannot be performed without hospital surgical facilities, and hospital beds data provides the best proxy available. Including other input variables would further aggravate the estimation difficulties due to the high collinearity of health care data.

Chapter Two indicated support for economic incentives having a bearing on variations in elective surgical rates. This chapter has shown that there has been sufficient variation in benefit rates over time and across provinces in Canada to warrant consideration of their role in explaining variations in the output of elective surgical procedures compared to other procedures.

Modelling the output response to changes in relative fees focuses on the key providers in the Canadian health care system. The key independent variables in an aggregate multiproduct profit function are specified in Chapter Four.

NOTES TO CHAPTER THREE

1 A comprehensive list of possible causes is provided by Abel-Smith (1983).

2 See Brown (1983) for details.

3 Calculated from confidential data provided by Health and Welfare Canada.

4 The subsequent definitions and descriptions of the four operations are from Dorland's Pocket Medical Dictionary (1977) and Harrison's Principles of Internal Medicine (1983).

5 Haemorroidectomy refers to the surgical removal of haemorrhoids, which are dilations of the veins, and are often associated with chronic infection. Conservative (non-surgical) treatment is often recommended.

6 A hernia is a protrusion of a portion of an organ or tissue through an abdominal opening. Those factors that increase intra-abdominal pressure can bring about hernias if weaknesses have developed in the abdominal region. If the hernia is small and asymptomatic, it is best left alone; perhaps a change of lifestyle involving less heavy lifting may be recommended. If it is painful or progressively enlarges so that other organs are threatened, surgery would be recommended, provided that the patient is not put at greater risk.

7 Cholecystectomy refers to the surgical removal of the gallbladder, due to the presence of gallstones. Lifestyle and a high calorie diet are major factors in the formation of gallstones. Most cholecystectomies are elective. The management of "silent gallstones" is controversial; gallstone dissolution is an alternative to surgery. Le Riche and Halliday (1983) in their study of Alberta surgical rates, noted that there was ".... some evidence that cholecystectomy is being used as a prophylactic [preventive] measure rather than a treatment for an acute problem" (p. 78).

8 Hysterectomy is the surgical removal of the uterus. The majority of hysterectomies are performed for elective purposes. See Notes to Chapter Two, #1.

9 See Notes to Chapter Two, #1.

10 See Brown, 1983, p.53.

11 In their study of Nova Scotia, Brown and Hicks (1983) found billing above tariff to be more prevalent with respect to office visits than for other categories of services. For family practitioners, 82 per cent of their over-billing was for office visits. However, over-billing for anaethesia was virtually non-existent, although 40 per cent of all anaethesia procedures in Nova Scotia had been administered by family practitioners. For specialists, the main service categories subject to over-billing were eye examinations (opthalmogists) and confinements (obstetrics/gynaecology).

12 Subsequent results were not altered materially when "total physicians" was the independent variable instead of "surgical specialists".

13 The federal minimum standards are set out in Instructions and Definitions for the Annual Return of Health Care Facilities (Part One), Health and Welfare Canada (1976).

14 Both reports quoted in LeClair (1975).

APPENDIX I - TABLE 3.1A

TOTAL ACTIVE PHYSICIANS, CANADA, 1973-1981

	1973	1974	1975	1976	1977	1978	1979	1980	1981
General Practice/ Family Medicine	13 628	15 543	16 379	17 036	17 654	17 913	18 469	18 853	19 232
Medical Specialties	5 238	6 154	6 449	6 745	7 071	7 257	7 551	7 866	8 257
Surgical Specialties	5 709	5 994	6 159	6 277	6 353	6 391	6 474	6 575	6 674
Other Specialties	2 729	3 417	3 559	3 676	3 762	3 851	3 927	4 029	4 121
TOTAL ACTIVE PHYSICIANS	27 304	31 108	32 546	33 734	34 840	35 412	36 421	37 323	38 284

Sources: Canada, Health and Welfare Canada (various issues) Health Manpower Inventory for 1973 to 1979 inclusive. Canada, Health and Welfare Canada (1983): Active Civilian Physicians by Type of Physician, December 31, 1981 for 1980 and 1981.

Note: Interns, residents and part-time physicans were excluded; the figures relate to the end of each calendar year.

APPENDIX I - TABLE 3.1B

TOTAL ACTIVE PHYSICIANS, BY PROVINCE 1973-1981

	1973	1974	1975	1976	1977	1978	1979	1980	1981
NF	433	545	591	633	640	644	654	684	716
PE	100	112	118	136	137	143	148	147	152
NS	910	1 039	1 085	1 136	1 186	1 255	1 249	1 271	1 284
NB	573	667	683	713	723	728	723	740	747
QU	7 244	8 317	8 748	9 148	9 521	9 654	10 051	10 218	10 550
ON	10 227	11 923	12 469	12 791	13 066	13 158	13 461	13 728	14 007
MA	1 184	1 353	1 428	1 476	1 490	1 516	1 518	1 554	1 587
SA	932	1 082	1 132	1 137	1 208	1 210	1 243	1 250	1 279
AL	1 984	2 234	2 310	2 399	2 533	2 624	2 700	2 792	2 946
BC	3 674	3 780	3 928	4 109	4 277	4 412	4 613	4 812	4 947
TERR	43	56	54	56	59	69	63	67	69
TOTAL	27 304	31 108	32 546	33 734	34 840	35 413	36 423	37 263	38 284

Source: Canada, Health and Welfare Canada (1982) and Health Manpower Inventory (various issues).
Note: The data in Appendix 3.I excludes interns and residents; the figures relate to October 1 of each year.

APPENDIX I - TABLE 3.1C

SURGICAL SPECIALISTS, BY PROVINCE, 1973-1981

	1973	1974	1975	1976	1977	1978	1979	1980	1981
NF	61	73	75	79	81	92	92	90	92
PE	18	18	18	24	25	25	25	26	25
NS	193	199	206	207	211	214	214	222	217
NB	143	155	160	157	158	160	160	166	169
QU	1556	1803	1874	1902	1926	1914	1958	1935	1980
ON	2046	2144	2218	2258	2269	2275	2299	2335	2377
MA	252	262	267	269	267	268	264	269	272
SA	162	176	188	190	194	194	194	185	197
AL	412	432	441	454	464	474	471	476	496
BC	720	714	721	730	750	764	789	804	840
TOTAL	5563	5976	6168	6270	6345	6380	6466	6508	6665

Source: See Table 3.1A.
Note: The figures relate to October 1 of each year.

APPENDIX II - TABLE 3.2A

HOSPITAL BEDS, GENERAL AND ALLIED SPECIAL HOSPITALS, BY PROVINCE, 1973-1981

	1973	1974	1975	1976	1977	1978	1979	1980	1981
NF	1 693	1 759	1 804	1 968	1 808	1 789	1 927	1 926	1 784
PE	418	420	421	421	422	426	428	436	442
NS	3 428	3 423	3 371	2 802	3 261	3 589	3 700	3 688	3 677
NB	2 777	2 769	2 793	2 830	2 776	2 788	2 784	2 751	2 747
QU	20 327	20 242	20 268	20 020	19 620	19 167	18 992	18 395	17 647
ON	29 043	28 711	28 682	28 488	27 180	27 004	26 183	25 610	26 204
MA	3 873	3 607	3 736	3 842	3 898	3 860	3 819	3 790	3 849
SA	4 743	4 649	4 670	4 662	4 647	4 589	4 519	4 431	4 420
AL	8 077	8 043	8 035	7 965	7 870	7 922	7 953	7 967	8 140
BC	8 304	8 442	8 479	8 431	8 372	8 377	8 338	8 285	8 432
TOTAL	82 683	82 065	82 259	81 429	79 854	79 511	78 643	77 279	77 342

Note: The figures have been adjusted by the author to relate to October 1 of each year.

CHAPTER FOUR

MODELLING PHYSICIAN OUTPUT MIX IN A MULTIPRODUCT CONTEXT

4.1 INTRODUCTION

What services are produced will depend on the resource allocation decisions made by the various economic agents in the economy. Economists judge the ideal standard of economic efficiency in resource allocation by the Pareto optimality criterion. With a Pareto optimal allocation of resources, it is not possible for an alternative allocation to make any party's position better without making another's worse off. Economic theory provides a framework for predicting and explaining the decisions of suppliers of labour services. Pareto optimality will result in an economy characterized by perfect competition. All agents are assumed to have perfect information about market prices, alternative technologies, and product and resource qualities. No individual agent believes he can affect the market price. In some situations, the decisions made by individuals who supply labour services (as do physicians) can be shown to be consistent with profit maximizing behaviour.

Several studies discussed in Chapter Two have lent support to the role of financial factors in explaining variations in elective surgical procedures. The health care delivery system creates incentives for providers to respond in certain ways and the literature suggests that the response to incentives is consistent with profit maximizing behaviour. Given the key role of physicians in allocating health care resources, a focus on providers is appropriate.

The medical care market does not conform in all aspects to the ideal of perfect competition; alternatives to neoclassical economic theory are proposed in explaining resource allocation decisions. A major cause of "market failure" is the asymmetry of information in the medical market. It is argued that providers will take advantage of their greater knowledge and induce demand, which manifests itself in the utilization data as over-servicing.

If demand inducement is admitted, and is unlimited, profit maximization could not be the behavioural objective which motivates physicians. An alternative behavioural rule utilizes a "target income" as the constraint as suppliers attempt to minimize "work effort". The performance of this alternative model, however, depends on the strength of the test for the demand inducement hypothesis and its explanatory power when compared with the neoclassical model. Criticisms of the use of the neoclassical model to characterize the supply of physicians' services are presented in Section 4.2, with special consideration given to the target income hypothesis as an alternative to profit maximization. Despite the alleged market failures, the traditional model is found to provide an appropriate framework for modelling the supply of physicians' services.

Differential variations in utilization and relative benefit rates were noted in Chapter Three. The fee structure may be such as to bias the output mix towards more remunerative procedures and this bias in favour of the more costly procedures has been noted in the literature as having a bearing on health system costs. Hospitals provide their facilities for elective surgical procedures without any direct charges to surgeons, but the surgeons' differential return from different procedures, at least for the elective category, may influence how hospital facilities are utilized. Case mix studies of hospital costs have confirmed the importance of multiple output approaches in explaining cost variations. However, such studies focus on hospitals as suppliers, rather than on physicians as suppliers who respond to the incentives embodied in the fee structure. In order to identify the service mix response by the key providers in the system to price changes, a model which includes physicians as suppliers of several different services must be developed. Following a discussion of limitations to the service mix approach in Section 4.3, a simple model of physician behaviour is introduced in Section 4.4. This model provides the basis for the use of a multiproduct profit function for surgical output which is specified in Section 4.5.

4.2 CRITICISMS OF THE TRADITIONAL ECONOMIC MODEL

The special features of the medical market are alleged to require something other than a neoclassical economic model to characterize the labour supply decisions of physicians. Major reasons for the inapplicability of the neoclassical competitive model are the asymmetry of information between consumer and provider and barriers to entry in the industry. These features give rise to possible exploitation by providers. In the medical market, the buyer is ignorant not only of the production process itself, but also of the health effects on the buyer. It is claimed that because of the reliance on the advice of the seller, the transaction will not be at arm's length (buyer and seller are not independent) - an assumption of the perfectly competitive model. Thus, there is a failure on the part of the physician to act as a perfect agent for the patient. While the perfectly competitive model predicts a decrease in prices, with an increased supply of physicians, ceteris paribus, the demand inducement hypothesis does not. It is based, in part, on the observation that prices for physician services have often been seen to increase even with increases in the numbers of physicians (Evans, 1974). The "target-income" approach, in which the target is achieved by means of inducing demand, has been suggested as an alternative behaviour hypothesis to profit maximization.

While it has been suggested that the standard economic model is inapplicable in analysing the market for medical care, the target income approach is not without its difficulties. How the target itself is set is not established. Newhouse (1978) cites empirical difficulties in formulating tests to identify supplier-induced demand. The observation that areas with high physician density also have high per capita utilization does not prove demand inducement; with initial excess demand the amount consumed might increase in the same proportion as supply, in which case it is not demand inducement. Further, a shift in the demand curve greater than that of the supply curve could explain rising equilibrium prices while supply has increased. Given the difficulty of identifying the existence of demand inducement itself, the target income hypothesis thus remains unsuitable as an alternative objective on which to base provider behaviour.

The perfectly competitive model assumes perfect knowledge on the part of buyers and sellers. What is often exchanged in the medical market place is information. Acquiring information can be incorporated into the marginal analysis of economic theory. Lack of knowledge is not unique to the medical market place and the extent of the information gap between physicians and consumers is questioned by Pauly (1978). He argues that it is only necessary that consumers be reasonably well-informed regarding the quality of medical care that they are purchasing. Pauly contends that for some medical services consumers will have sufficient information, some of it based on experience, to make an informed choice. In obtaining information, consumers will weigh the marginal costs against the marginal benefits. Despite the likelihood that consumers will be less well-informed regarding elective surgery, since they are likely to have had little prior knowledge of the procedures, and the marginal costs of obtaining the required knowledge are high, there is still a limit to demand inducement if information costs are considered. Coyte (1985) has also shown that when consumer monitoring costs are considered, the traditional model incorporating maximizing behaviour is appropriate and provides predictions consistent with the observed positive association between bed availability and bed use and between the supply of physicians and the level of fees [Feldstein (1974), Pauly (1980)]. Thus, if the cost of information is included in the decision calculus, the neoclassical individual choice model is applicable to the allocation of a physician's time to competing activities.

The output of many health sector units is complex; these units can be characterized best as multiproduct units. While multiple inputs have been taken into account in various aspects of supply estimation, there are fewer examples of multiple output models. The output mix, which has a bearing on the costs of the health care system, is influenced by financial incentives, the most obvious being the structure of fees. Section 4.3 highlights the multiproduct nature of health care output and considers difficulties associated with focusing on the hospital rather than on the physician as the supplier of services.

4.3 THE MULTIPRODUCT NATURE OF HEALTH CARE OUTPUT

A physician's time is an important input in the production of physician services, and it is evident that there are alternative uses of this time. The multiple output nature of hospitals is clear from the wide range of different services provided to patients and from the ranges of conditions treated: the same hospital facilities can be utilized in a variety of surgical and non-surgical procedures, and the same hospital beds and nursing staff are available in the course of treatment associated with many different patient conditions. The many alternative uses of the health care inputs provides strong support for investigating the output mix and its determinants, rather than examining exclusively the input mix. The output mix itself is affected by financial factors, given the constraints imposed by existing medical technology.

Most studies of case mix have focused on the costs of hospital services. The multiproduct nature of health output has been recognized in attempts to account for variations in hospital costs. The specialized facilities required in major surgical operations could account for certain hospitals having higher costs.

Although the practical importance of the case mix has been confirmed, analytical difficulties with this approach remain. Tatchell (1983) reviewed approaches to hospital cost analysis based on case mix and service mix (in terms of the facilities provided by hospitals). He notes that service requirements are not always captured accurately by the case mix measures. Thus costs may not be accurately reflected in case mix variations. The information theory technique, often used in case mix studies, is based on the idea that the occurrence of a rare event involves a greater information gain than the occurrence of a common one. However, while a rare disease has a high complexity rating, it may not be costly to treat. Also, variations in complexity within a specific category are not captured adequately. The severity of illness affects costs, and severity differs within diagnostic categories. For example, diabetes is given a low complexity ranking, but the disease includes some patients with mild diabetes and others with renal and cardiac complications. Rather than being an indication of a low level of complexity, some health services (such as emergency facilities), are widely dispersed in order to be available for immediate treatment. For a given population of potential users, common facilities do not imply a common case mix in terms of the actual cases treated. The availability of services, captured in the service mix measure, is no guarantee that the facilities were used in any given period and hence resulted in costs being incurred.

Cowing and Holtman (1983) confirmed the positive relationship between total variable costs and the output of four of their five diagnostic categories - emergency room treatment, medical-surgical care, maternity care and other types of care. (Pediatric care was found to be unrelated to total variable costs.) Unfortunately, the medical-surgical category is not subdivided. The positive elasticity for hospital costs with respect to the number of admitting physicians was "...consistent with the notion that physicians over-use hospital services - perhaps to protect themselves against malpractice suits or to assure quality care without much regard for costs - or the notion that physicians may create demand for their own services" (p.643)[1].

The case mix approaches are oriented to the explanation of cost variations based on case mix and service mix with the hospital as the supplier. Studies of hospital cost variations have confirmed the multiple output nature of health output, and although hospital facilities are used in the performance of elective surgical procedures, the return to physicians is not explicitly considered as a variable affecting the resulting utilization mix. The following section introduces a simple model of an individual decision maker who can allocate time to leisure and two income-providing services. In this model, the returns to the services which the individual may supply may affect the resulting mix of services provided.

4.4 A SIMPLE MODEL OF TIME ALLOCATION TO LEISURE AND TWO SERVICES

While physicians "produce" outputs, they also make decisions about the allocation of time to work effort and leisure. The profit maximizing decision should be derived ultimately from an individual utility maximization model. Suppose the physician receives utility from the consumption of goods purchased at a price, P, and from the consumption of leisure time, L. The physician's utility for a given period of time can be expressed as

$$U = U(X, L) \tag{4.1}$$

where X is the quantity of goods purchased and L is the leisure time chosen. Goods are purchased with income earned by selling services. Assume that two services are sold, at prices W_1 and W_2. The supply of services are measured as S_1 and S_2, and so total income, which equals expenditure on goods, is represented as

$$X P = W_1S_1 + W_2S_2 \tag{4.2}$$

Using equation (4.2), equation (4.1) may be expressed as

$$U = U [L, (W_1S_1/P) + (W_2S_2/P)] \tag{4.3}$$

The constraint faced by the physician is given by

$$H = L + T_1 + T_2 \tag{4.4}$$

where H is total time available to the physician and T_1 and T_2 is the time allocated to service 1 and service 2, respectively. The time necessary to perform any level of services 1 and 2 is represented by

$$T_1 = f(S_1) \tag{4.5}$$

$$T_2 = g(S_2) \tag{4.6}$$

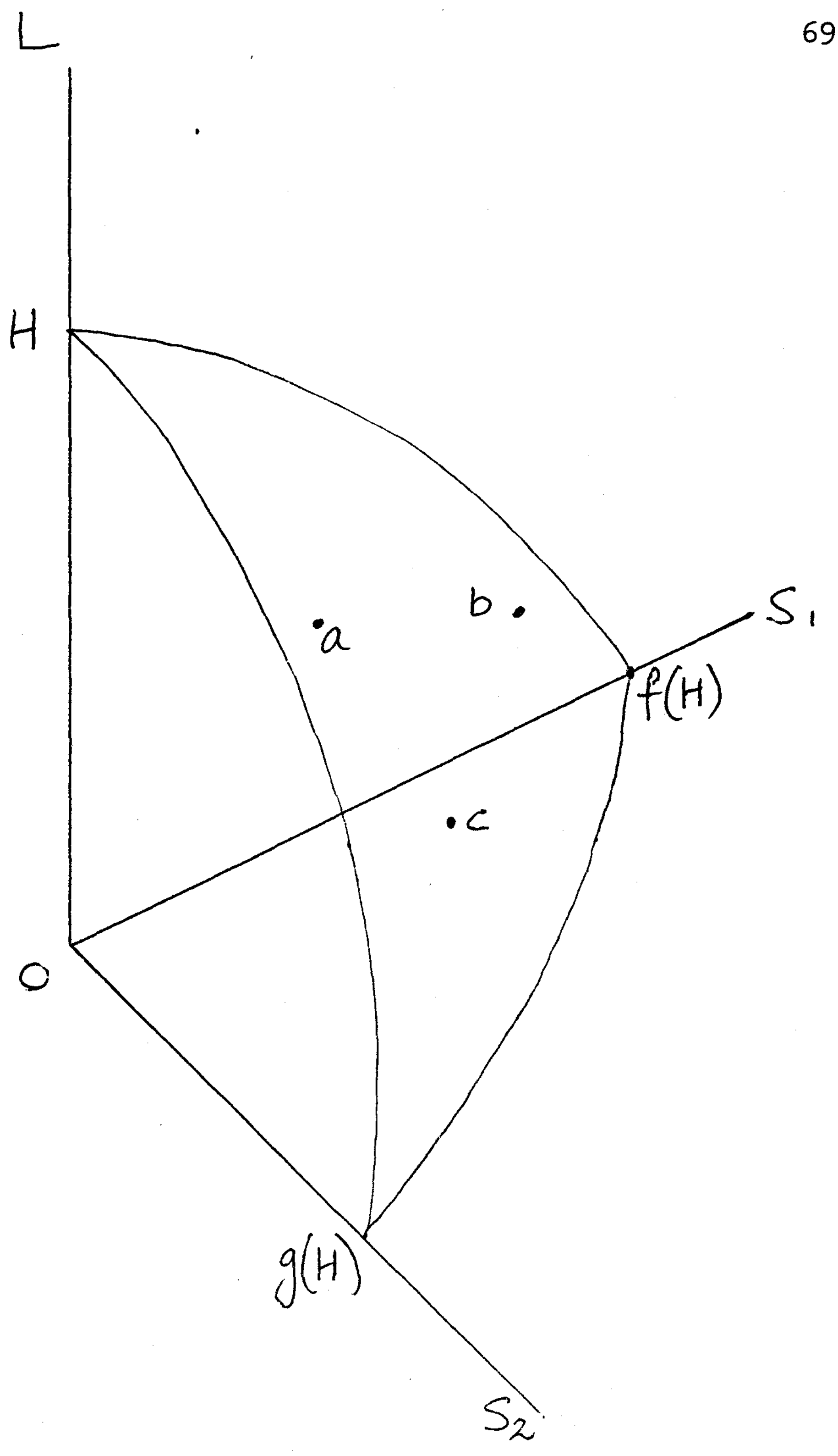

FIGURE 4.1

Substituting equations (4.5) and (4.6) into equation (4.4), the budget constraint can be expressed as

$$H = L + f(S_1) + g(S_2) \qquad (4.7)$$

If the amount of time necessary to perform a service increases as its volume increases, the constraint defined by equation (4.7), expressed in terms of leisure time chosen by the physician and the amount of each service performed, can be represented by Figure 4.1. The physician is assumed to maximize utility subject to the budget constraint (4.7), given the prices of goods and services.

As the prices of the goods consumed by the physician and the wages (fees) received for the physician's services vary, points such as a, b, and c may be chosen. If data generated over time indicate that L does not change as the price of goods and services vary, the resulting points on the constraint frontier will appear as m, n, and r in Figure 4.2.

If data consistent with points m, n, and r in Figure 4.2 occur, the total time allocated to the provision of services 1 and 2 does not vary (although the time allocated between services 1 and 2 may vary substantially). This implies that the maximization of utility by the physician requires the maximization of

$$U = U(L^*, X) \qquad (4.8)$$

where L^* is the invariant level of leisure chosen and X is the consumption of goods by the decision maker.

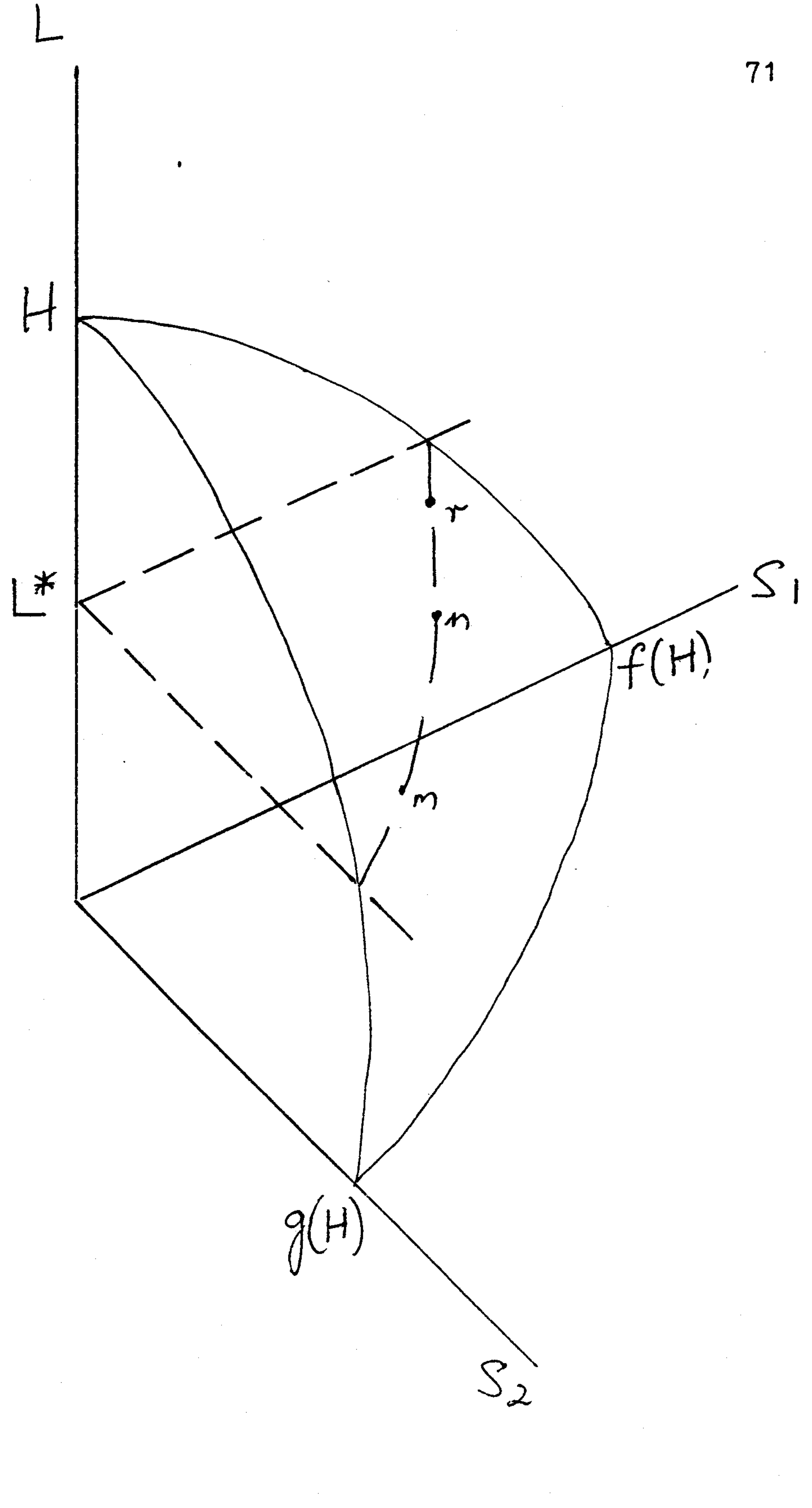

FIGURE 4.2

To maximize utility, the physician would maximize

$$P\dot{X} = W_1S_1 + W_2S_2 \qquad (4.9)$$

subject to

$$H - L^* = f(S_1) + g(S_2) \qquad (4.10)$$

In the context in which inputs are provided at no charge to the physician (as they are by the hospital when the physician performs services in an operating room), the maximization of (4.9) subject to (4.10) implies the maximization of the physician's profit from providing services 1 and 2. Equation (4.10) is represented in Figure 4.3 as the non-linear constraint and the objective function (4.9) is indicated by the linear iso-profit contours. The preferred point is I, where the iso-profit contour with the greatest value touches the constraint. Changes in the price of service 1 relative to the price of service 2 will lead to changes in the mix of services which will maximize the physician's utility.

Work by Roos (1983) suggests that L tends to be invariant over time for physicians; this provides support for the assertion that physicians' allocations of time between professional activities may be modelled as profit maximizing behaviour even though physicians are not firms but are individuals who must make leisure/labour choices and consumption decisions which may all be interdependent. The key variables for the specification of a multiproduct profit function for physicians, from which supply equations can be derived, are outlined in Section 4.5.

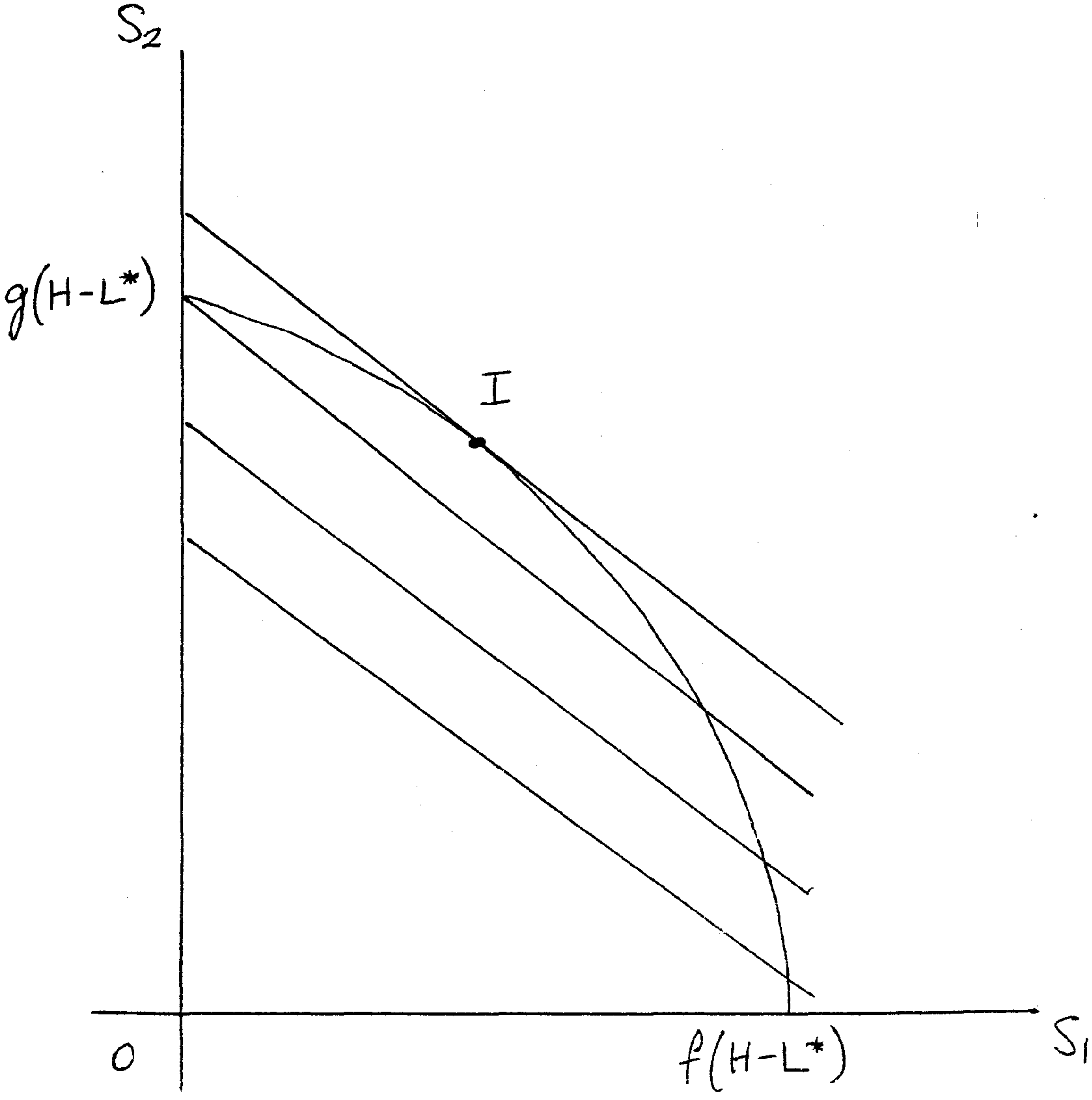

FIGURE 4.3

4.5 SPECIFICATION OF A MULTIPRODUCT PROFIT FUNCTION FOR SURGICAL OUTPUT MIX

Full insurance renders the money price of a medical procedure to the patient zero at the point of service. With the removal of this constraint from the demand side of the medical care market, and the lack of urgency in the treatment associated with elective surgery, a greater emphasis on the financial incentives facing providers is appropriate. Physicians might respond by allocating their time on the basis of the marginal revenue (that is, the fees) associated with the various services. One would expect the supply of an elective surgical procedure to be dependent not only on its own price (as indicated by the provincial benefit schedule), but also on the prices of other elective procedures. Testing this hypothesis requires a multiproduct specification of the production function which characterizes the physician-firm. A multiproduct specification of an aggregate production function for surgical services enables testing for changes in the output mix in response to relative price changes, assuming profit maximization.

Supply equations derivable from neoclassical production theory contain product prices, factor prices and factor input quantities as independent variables. While Pauly (1980) recognizes the structure of insurance fee schedules as a possible cause of the over-provision of many physician services, he does not incorporate this structure into his testing of the availability effect on the demand side, since he includes only one price index in the regressions. To account for substitution on the basis of responses to marginal revenues, a multiple output specification of supply equations is required, with the output price and the other relevant prices included as independent variables. Given the incentives inherent in the insurance schedules, if physicians behave in a manner consistent with profit maximization, adaptations of standard economic theory are appropriate. Differential increases in the fees for different procedures, as discussed in Chapter Three, would then be expected to provide incentives to alter service mix over time.

While the effects of physician decisions manifest themselves in realized hospital expenditures, the studies of hospital costs do not focus on the fee structure for surgical procedures and other procedures and on the incentive for physicians to change their "practice mix" in favour of the more expensive procedures. The fees received for surgical services relative to other uses of physician time are the key decision variables. With the introduction of government sponsored medical insurance in Canada, it is reasonable to treat physicians as price takers, responding to provincial benefit schedules. (Censure regarding price cutting ensures that individual physicians behave as price takers.)

Negotiations <u>within</u> the medical profession are not made public. Representatives of the individual specialties determine procedure fees; the government does not participate in the negotiations between specialties. To some extent, now that governments determine the global budget allocated to health care expenditures, the fees reflect the relative bargaining powers of various medical specialties. Given the assumed validity of the profit maximizing postulate, a duality approach to analysing physician responses to the financial incentives facing them within the health care delivery system is a step in considering the magnitude of price responses in the field of elective surgical procedures.

The cost structure of physician practices in Canada has not been determined. Almost all ancillary resources used in surgical procedures are provided to doctors free, subject only to access to hospital privileges. The costs of anaethesists, nursing services, drugs, operating facilities and hospital beds, for example, are not charged to doctors, and so would not appear explicitly in the specification of their objective functions. Since such costs do not enter the objective function of surgeons, a multiproduct profit function, rather than a cost function[2], is an appropriate starting point. Further, the specification of the resulting supply equations will not have factor prices as independent variables.

4.6 SUMMARY

Financial factors may play a key role in service mix, and in contributing to a rate of elective surgical procedures in excess of that warranted by morbidity patterns. With first dollar coverage under universal, government sponsored health insurance, the monetary cost to patients at the point of service is zero; a crucial financial constraint to patient demand is thereby removed and the emphasis of a study of health care system costs turns to the variables determining physician decisions. It has been argued that models of profit maximizing behaviour can be applied to analyse aggregate physician behaviour regardless of the market structure.

Service requirements, and hence costs, are not always captured accurately by the case mix measures; complex cases do not always imply higher costs and severity may vary considerably within diagnostic grouping. A rare disease will receive a high complexity rating although it may not be costly to treat. A multiproduct specification, with emphasis on supply equations, will highlight the contribution of prices other than the own-price of the operation being considered, in addition to the non-price factors crucial to the operation, such as hospital beds and the number of surgical specialists.

The output mix will influence overall costs of the health system, and elective surgical procedures have come under scrutiny with regard to over-servicing, and hence their possible contribution to excessive costs. In the following chapters we focus, at the aggregate level, on the magnitude of the output mix response to variations in relative fees. No attempt is made to model individual physician practices, for which data are not available. Supply is dependent on the technology constraints embodied in the production function, but direct estimation of the production parameters is not always possible. The limitations inherent in the data and lack of knowledge of intermediate production relations can sometimes be overcome by the application of duality principles, our next topic.

NOTES TO CHAPTER FOUR

1 Cost minimizing behaviour by the hospitals is implicit in the multiproduct translog variable cost function that formed the basis of the estimations. "...(I)t is difficult.... to understand the meaning of a relationship without this basic behavioural assumption." (p.638).

2 Burgess (1975) found that the results obtained from the specification of a translog production function differed from those obtained from the translog cost function. While the Cobb-Douglas and the CES functional forms possess the property of "self-duality", that is, the production and cost functions are members of the same family of functional forms, the translog form and others that avoid the additivity restrictions, are not "self-dual." A translog production function does not possess a corresponding cost function that is also a translog form. Thus, "...the decision whether to focus on the primal problem and specify a production function or focus on the dual problem and specify a cost function involves a choice between two different representations of the technology" (p.120). The results obtained in this study for surgical output mix cannot be tested for sensitivity to the initial specification of the technology due to data limitations.

CHAPTER FIVE

DUALITY THEORY AND THE CHOICE OF FUNCTIONAL FORMS

In order to determine the responsiveness of output mix to changes in relative prices, a multiproduct approach to supply estimation is required. A change in output mix in response to changes in relative prices can be depicted as a movement along a production hyper-surface or, in two dimensions, as a movement along the production possibility frontier, and the elasticities of transformation and price elasticities measure the responsiveness of supply to proportionate changes in prices, given that the price line is tangent to the production possibility frontier. However, often it is not possible to estimate the parameters of the frontier directly because data for intermediate inputs are incomplete or because information on input allocation to specific outputs is lacking. These difficulties in specifying the production function for a multiproduct technology may be overcome by estimating the dual profit or cost function.

In production theory there are two approaches to solving for the profit maximizating output. The first approach requires the specification a functional form for the multiproduct production function and the use of the Lagrangian technique to solve the constrained profit maximization or cost minimization problem. The second approach starts from observed economic data and requires the specification of a differentiable functional form for the profit or cost function. Systems of supply equations or derived input demand equations are obtained by differentiation of the profit or cost function, respectively. The second method is favoured for econometric applications since, if a second order approximation to the relevant function is required, it is usually impossible to obtain an explicit function for the supply equations from the original production function due to the difficulty of specifying the original multiproduct technology.

The theory of production duality establishes the above two approaches as equivalent. Shephard (1970) and Uzawa (1964) showed that a firm's technology could be equally well represented in terms of a production function or a cost function, and McFadden (1978) extended these results to profit and revenue functions. [Diewert (1971) presents proofs of these duality theorems for the generalized Leontief production function.] In Canada, key resources for surgical procedures are provided by the hospital, and cost data for physician practices are not available. It is therefore appropriate to focus the discussion on the dual profit function and the relevant supply equations, which permits an analysis of output responses despite severe data limitations. A variable profit function, such as specified by Diewert (1973) and Woodland (1977), is appropriate since the choice of output mix will involve some fixed factors.

In order for the duality principle to be applied, the profit function must exhibit certain properties consistent with the economic theory of the firm. The profit function is a real valued function of prices. It is non-increasing in factor prices (an increase in factor prices does not increase profits) and is non-decreasing in product prices (an increase in output price will not result in decreasing profits). Positive profits are implicit in the constraint of a non-negative profit function. The profit function is convex and homogeneous of degree one in product prices. The implication of the assumption of homogeneity of degree one (linear homogeneity) in output prices is that only relative prices enter the economic decision process.

A further result useful in production theory is Hotelling's lemma, which states that given a profit function with the properties described above, its derivatives with respect to product prices will yield the profit maximizing outputs, (and the derivatives with respect to factor prices would yield negative profit maximizing factor demands). Supply equations can thus be derived from the profit function for the four elective surgical procedures considered by differentiating the profit function with respect to the relevant prices.

To obtain a preliminary indication of output responses to price changes, double logarithmic supply equations were estimated, although a profit function in the Cobb-Douglas form is viewed as a first order expansion only. The Cobb-Douglas form is linear in its parameters and the elasticities can be read directly from the coefficients. However, in order to derive supply equations that have prices as independent variables, second order approximations are required, where properties of the profit function are exhibited locally within the given data set, rather than globally. Flexible functional forms represent a class of functions that provide second-order approximations to arbitrary functions, and permit econometric testing of the substitution possibilities instead of imposing specific substitution constraints at the outset through the choice of functional form, as happens with the Cobb-Douglas and CES forms (see Denny, 1974).

Given the variety of possible functional forms within the subset of flexible functional forms, the criteria for choice of a specific function is addressed by Fuss et al. (1974). In addition to being well-behaved within the observed data set, in the sense of giving convex isoquants, appropriate statistical properties must be considered in the light of cost constraints on computer use. Linearity in the parameters is desirable in this respect, since the techniques of linear regression analysis can be applied. Estimation of a system of equations will be costly, so the relative ease with which estimates can be obtained is an important consideration. A functional form amenable to hypothesis testing regarding returns to scale and homogeneity is an advantage.

Estimation of flexible functional forms entails many coefficients. In econometric estimation, tests for statistical significance are employed in determining the extent to which variations in the dependent variable are "explained" by variations in independent variables. In performing tests to determine the statistical significance or reliability of the estimates of the coefficients from a sample, the concept of "degrees of freedom" is important. Where the sample size is small and there are many parameters (in relation to the number of observations), degrees of freedom are lost. Many parameters will also aggravate the multi-collinearity problem inherent in economic data. A further advantage of employing Hotelling's lemma is thus indicated; the derivation of supply equations from the variable profit function reduces the number of parameters to be estimated and hence conserves degrees of freedom. In addition, although the assumption of price-taking behaviour is not essential for the application of duality theory (see Diewert, 1974), price-taking behaviour buys degrees of freedom in the econometric estimation (see Diewert, 1973).

Diewert (1973, 1974) and others discuss a variety of flexible functional forms and their empirical properties. Two specific functional forms which satisfy the conditions imposed on the form of the profit function and meet the criteria on the choice of appropriate functional forms are the translogarithmic (translog) form and the generalized Leontief form. The results of the econometric estimation based on these functional forms are presented in Chapter Six.

CHAPTER SIX

MULTIPRODUCT ESTIMATION AND RESULTS FOR SURGICAL SUPPLY EQUATIONS

6.1 INTRODUCTION

The influence of financial factors in physician supply decisions regarding elective surgical procedures has been suggested by a number of studies referred to in Chapter Two. The analysis of coefficients of variations presented in Chapter Three indicates variations in relative benefit rates across and within provinces among the different prices as well as across Canada over time. The literature suggests that the response of providers to incentives is consistent with profit maximizing behaviour. Despite the alleged market failures in the medical care market, the traditional model is an appropriate framework for modelling the supply of physicians' services. In particular, price-taking behaviour on the part of physicians, the key decision makers in the health care system, is a reasonable assumption under national health insurance. Supporting the assumption of price-taking behaviour are the studies of opting-out that have found that over-billing is below average for surgical services.

Direct estimation of the supply parameters from the production possibilities set is impossible due to lack of information on intermediate inputs and other data limitations. An alternate approach is to estimate the supply equations which can be derived from a profit or revenue function of the translog or generalized Leontief form. The principles of duality theory establish this approach as theoretically equivalent to the first. Hence, econometric estimation of the supply equations is made possible by the application of the principles of duality theory.

Supply equations for four elective surgical procedures based on the translog and generalized Leontief profit functions are estimated. The responsiveness of supply to changes in relative prices and also to changes in numbers of hospital beds and surgical specialists per thousand population is measured by supply elasticities. A dynamic specification is given by including supply lagged one period as an independent variable in each supply equation.

Pooled cross-section and time series data for the ten provinces are used in deriving estimates of the coefficients. Differences in the sizes of the provinces are allowed for by reporting the estimates on a per thousand population basis.

Preliminary measures of price responsiveness based on ordinary least squares estimates are presented in Section 6.2. The relative price variables are entered in forms consistent with the systems estimations discussed subsequently - - that is, the forms are consistent with the translog form of the price variable ($\ln P_{ij}$) and the generalized Leontief form (P_j/P_i). Multicollinearity was evident in some of the ordinary least squares equations, and possible econometric techniques to offset its effects were considered. Another objective was to compare the effects of the functional form on the parameter estimates. The translog profit function and the results derived from the system of translog revenue share equations are presented in Section 6.3. The results for the generalized Leontief system of supply equations are contained in

Section 6.4. Section 6.5, based on the results from the generalized Leontief variable profit function, completes the chapter.

6.2 ORDINARY LEAST SQUARES RESULTS

A. ORDINARY LEAST SQUARES RESULTS CORRESPONDING TO THE TRANSLOG FORM.

The double logarithmic form of the supply equations corresponds to the translog revenue share system. Its linearity facilitates econometric estimation, and the short-run elasticities of the quantity of output with respect to the independent variables can be read directly from the estimated coefficients.

The equations are of the following general form

$$\ln Q_{ikt} = \alpha_i + \sum_{j=1}^{4} \beta_{ij} \ln P_{ijkt} + \sum_{k=1}^{10} \delta_{ik} D_k \ln P_{okt} + \phi_i \ln HPOP_{kt} + \gamma_i \ln SPOP_{kt} + \theta_i \ln Q_{ik,t-1} + \varepsilon_{ikt} \tag{6.1}$$

where Q_{ikt} refers to the number of operations of i^{th} type per thousand population; P_{ijkt}, the price of the j^{th} operation in the i^{th} equation; P_{okt}, the price index for all other procedures; $HPOP_{kt}$ is the number of hospital beds per thousand population and $SPOP_{kt}$ refers to the number of surgeons per thousand population; $Q_{ik,t-1}$ is the dependent variable, lagged one period. D_k is the dummy variable denoting the k^{th} province. Ln refers to the logarithm of the variable. The four types of operations are: i=1, Haemorroidectomy (HM); i=2, Inguinal Herniorraphy (IH); i=3, Cholecystectomy (CH); and i=4, Hysterectomy (HT). The error term, ε_{ikt}, renders a stochastic specification to the model. (The error term is assumed to be normally distributed with constant variance, σ^2.)

Since the analysis was confined to the period after the introduction of medicare in all provinces, there were too few observations to estimate supply equations for each province separately. Instead, the acknowledged provincial differences were represented only by dummy variables. Dummy variables representing the provinces were finally presented as adjustments to slope coefficients of the weighted price index of all other procedures (P_{okt}) instead of adjustments to the intercepts. (Only the estimates for δ_{ik} are specific to each province.)

Economic theory predicts a positive supply response to changes in own-prices. An increase in a benefit rate of one operation relative to others would be expected to result in an increased number of the higher-valued procedures being performed. Substitution in production is indicated by negative cross-price elasticies. A positive coefficient is expected for hospital beds per thousand population. For a given population, the coefficient for surgeons per thousand population may be positive or negative. Adjustments to changes in benefit rates are expected to take time; to account for this, supply lagged one year is included in each equation. The estimated coefficients[1] are presented in Table 6.1.

TABLE 6.1

OUTPUT SUPPLY PARAMETERS ESTIMATED BY ORDINARY LEAST SQUARES (TRANSLOG FORM) - CANADA - (1973 - 1981)

VARIABLE	HAEMORROIDECTOMY		INGUINAL HERNIORRAPHY		CHOLECYSTECTOMY		HYSTERECTOMY	
Ln P_{HMkt}	- .0181	(- .12)	- .0692	(- .75)	- .0818	(- .70)	.1359	(1.34)
Ln P_{IHkt}	.0715	(.34)	.0753	(.57)	.3074	(1.88)	.2581	(1.79)
Ln P_{CHkt}	- .3043	(-1.57)	- .0956	(- .83)	- .6065	(-4.20)	- .5544	(-4.23)
Ln P_{HTkt}	- .1329	(- .66)	- .0772	(- .62)	.0532	(.34)	.0720	(.55)
D_{NF} Ln P_{okt}	- .0813	(- .58)	- .0016	(- .02)	- .0799	(- .72)	- .0935	(-1.00)
D_{PE} Ln P_{okt}	- .0433	(- .31)	.0504	(.60)	- .0662	(- .61)	- .0974	(-1.04)
D_{NS} Ln P_{okt}	- .0625	(- .45)	.0245	(.29)	- .0631	(- .56)	- .0778	(- .82)
D_{NB} Ln P_{okt}	.0025	(.02)	.0195	(.23)	- .0845	(- .74)	- .1006	(-1.05)
D_{QU} Ln P_{okt}	.0175	(.12)	.0315	(.35)	- .0504	(- .43)	- .1197	(-1.19)
D_{ON} Ln P_{okt}	- .0271	(- .18)	.0542	(.60)	- .0790	(- .67)	- .1426	(-1.40)
D_{MA} Ln P_{okt}	- .0611	(- .40)	.0398	(.44)	- .0701	(- .59)	- .1798	(-1.71)
D_{SA} Ln P_{okt}	- .0518	(- .36)	- .0063	(- .07)	- .1012	(- .87)	- .1741	(-1.74)
D_{AL} Ln P_{okt}	- .0275	(- .18)	.0139	(.15)	- .0614	(- .52)	- .1042	(-1.03)
D_{BC} Ln P_{okt}	- .0012	(- .01)	.0324	(.36)	- .0666	(- .57)	- .1121	(-1.13)
Ln $HPOP_{kt}$	.4067	(1.87)	.1935	(1.41)	.1706	(.96)	.0400	(.28)
Ln $SPOP_{kt}$	.3663	(1.88)	.1671	(1.32)	.0333	(.22)	.2155	(1.59)
Ln $Q_{ik,t-1}$	.2699	(2.36)	.3611	(3.11)	.6169	(7.00)	.4198	(4.23)
Constant	1.9674	(2.41)	1.4010	(2.65)	2.3915	(3.24)	2.1316	(3.75)
R^2 (adj)	.8600		.8500		.9220		.9200	

Note: 1. The critical t-statistic for a two-tailed test at the 10 per cent level of significance with 17 degrees of freedom is 1.74 (t-statistics are in brackets).
2. The equations correspond to the translog form; the coefficients are (short-run) elasticities.

For this functional form, the own-price elasticities with the expected positive sign appear in equation 2 (IH) and in equation 4 (HT). However, they are not statistically significant at the ten per cent level. (All tests for statistical significance are conducted at the ten per cent level). The negative sign for CH in equation 3 is unexpected. There is little support for substitution among the four elective procedures as evidenced by only 7 negative signs on the 12 cross-price terms. (The cross-price elasticities cannot be interpreted as relating to substitution in consumption by patients; the correct interpretation is in terms of physician time.) The strongest evidence for substitution in production is in equation 4 (HT); hysterectomies are supply substitutes for cholecystectomies, as indicated by the negative and statistically significant estimated coefficient for ln P_{CHkt}. In equation 1 (HM), there is evidence of substitution between haemorroidectomies and changes in the price of cholecystectomies (consistent with equation 3).

Stronger evidence of substitution is found in the response to proportionate changes in P_{okt}. For equations 3 (CH) and 4 (HT), the negative signs indicate substitution between cholecystectomies and other procedures and between hysterectomies and other procedures. With the exception of only two provinces for equation 1 (HM), the expected negative signs indicate substitution between haemorroidectomies and other procedures. The variable $HPOP_{kt}$ representing hospital beds per thousand population has the expected positive sign in all cases, but is statistically significant for haemorroidectomies. Positive signs occur for $SPOP_{kt}$ in all equations.

TABLE 6.2

LONG-RUN SUPPLY ELASTICITIES DERIVED FROM ORDINARY LEAST SQUARES RESULTS (TRANSLOG FORM) - CANADA - (1973 - 1981)

	HM	IH	CH	HT
P_{HM}	- .07	- .19	- .13	.32
P_{IH}	.26	.21	.50	.61
P_{CH}	-1.13	- .26	- .98	-1.32
P_{HT}	- .49	- .21	.09	.17
NFP_O	- .30	- .00	- .13	- .22
PEP_O	- .16	.14	- .11	- .23
NSP_O	- .23	.07	- .10	- .19
NBP_O	.01	.05	- .14	- .24
QUP_O	.06	.09	- .08	- .29
ONP_O	- .10	.15	- .13	- .34
MAP_O	- .23	.11	- .11	- .43
SAP_O	- .19	- .02	- .16	- .41
ALP_O	- .10	.04	- .10	- .25
BCP_O	- .00	.09	- .11	- .27
HPOP	1.51	.54	.28	.10
SPOP	1.36	.46	.05	.51

Note: Based on Table 6.1 parameter estimates.

The lagged dependent variables have the expected positive signs and are statistically significant. The long-run elasticities based on the parameter estimates of Table 6.1 are presented in Table 6.2. As expected, these elasticities are greater than the short-run elasticities.

The estimated price responses are low. This might possibly result from the specification of the relative price term. Alternative specifications of the price variables similar to the generalized Leontief form are considered next.

B. ORDINARY LEAST SQUARES RESULTS CORRESPONDING TO THE GENERALIZED LEONTIEF FORMS

In the OLS specifications that correspond with the generalized Leontief form, own-price enters in the denominator of the equation. Various equations have been estimated, but only two forms are discussed, since the price responses were found to be similar. In the first form, $HPOP_{kt}$ and $SPOP_{kt}$ enter additively, and in the second they enter multiplicatively, with constant returns to scale imposed. While attaching dummy variables representing the provinces to both $HPOP_{kt}$ and $SPOP_{kt}$ in the same equation may be desirable, the resulting coefficients are highly collinear and given the constraints on data availability, degrees of freedom rapidly decrease. Hence the dummy variables representing provinces were attached only to the relative price terms $(P_o/P_i)_{kt}$.

The general form of the first equation is

$$Q_{ikt} = \sum_{j=1}^{4} \beta_{ij} (P_j/P_i)_{kt} + \sum_{k=1}^{10} \delta_{ik} D_k (P_o/P_i)_{kt} + \phi_i HPOP_{kt} + \gamma_i SPOP_{kt} + \theta_i Q_{ik,t-1} + \varepsilon_{ikt} \quad (i \neq j) \tag{6.2}$$

where the variables are as defined previously.

The parameter estimates where $HPOP_{kt}$ and $SPOP_{kt}$ are entered additively are presented in Table 6.3. With the own-price in the denominator in equation (6.2), substitution within the four procedures is represented by a negative sign. For example, an increase in the price of hysterectomy operations relative to the price of other procedures results in a decrease in the relative price ratio $(P_o/P_{HT})_{kt}$ and hence would be expected to result in an increase in the number of hysterectomies (per thousand population) performed. This expectation is supported strongly (see Table 6.3) for the case of hysterectomies; the expected negative signs are present in all provinces, with statistically significant coefficients for Manitoba (MA) and Saskatchewan (SA). There is support also for HM, but not for IH or CH.

The lagged dependent variable has the expected positive sign and is statistically significant in all cases. This dynamic specification thus suggests that an inertia model of adjustment applies.

Hospital beds per thousand population ($HPOP_{kt}$) have the expected positive sign in the equations for HM (equation 1), IH (equation 2) and HT (equation 4), with statistically significant results obtained for equations 1 and 4. An increase in $SPOP_{kt}$ (surgical specialists per

TABLE 6.3

OUTPUT SUPPLY PARAMETERS ESTIMATED BY ORDINARY LEAST SQUARES. (GENERALIZED LEONTIEF FORM I) - CANADA - (1973-1981)

VARIABLE	HAEMORROIDECTOMY		INGUINAL HERNIORRAPHY		CHOLECYSTECTOMY		HYSTERECTOMY	
$(P_j/P_i)_{kt}$	- .13	(- .93)	.11	(.28)	- .01	(- .01)	2.13	(2.43)
	- .02	(- .25)	.02	(.11)	.49	(.48)	.93	(1.19)
$j \neq i$	.14	(1.77)	.13	(.59)	1.70	(2.92)	- .94	(-1.95)
$D_{NF}.B$	- .62	(-1.94)	- .40	(- .52)	-1.43	(- .58)	-1.67	(- .96)
$D_{PE}.B$	- .36	(-1.13)	1.02	(1.43)	-1.16	(- .50)	-1.14	(- .65)
$D_{NS}.B$	- .54	(-1.46)	- .10	(- .12)	2.00	(.76)	-1.46	(- .78)
$D_{NB}.B$	.00	(.01)	.28	(.33)	.58	(.21)	-1.94	(- .96)
$D_{QU}.B$	.19	(.42)	.30	(.30)	.81	(.27)	-1.69	(- .71)
$D_{ON}.B$	- .23	(- .51)	1.06	(1.06)	- .05	(- .02)	-3.37	(-1.34)
$D_{MA}.B$	- .64	(-1.42)	.33	(.32)	- .85	(- .26)	-6.06	(-2.10)
$D_{SA}.B$	- .72	(-1.80)	- .93	(- .89)	- .49	(- .15)	-7.38	(-2.89)
$D_{AL}.B$	- .63	(-1.53)	- .65	(- .66)	- .30	(- .10)	-3.35	(-1.45)
$D_{BC}.B$	- .07	(- .16)	.27	(.28)	1.16	(.38)	-1.75	(- .74)
$HPOP_{kt}$	.09	(2.53)	.13	(1.57)	- .06	(- .54)	.24	(3.11)
$SPOP_{kt}$	.34	(.52)	1.62	(1.30)	-3.59	(-2.06)	1.42	(.82)
$Q_{ik,t-1}$	.52	(4.97)	.51	(4.62)	.88	(15.00)	.55	(5.50)

Notes:
1. P_i refers to the own-price in each equation. B denotes $(P_o/P_i)_{kt}$ attached to the provincial dummy variables.
2. The intercept has been suppressed to retain consistency with the Generalized Leontief form.
3. Hospital beds per thousand population ($HPOP_{kt}$) and Surgical Specialists per thousand population ($SPOP_{kt}$) are entered additively.
4. The critical t-statistic for a two-tailed test at the 10 per cent level of significance with 16 degrees of freedom is 1.746 (t-statistics are in brackets).

thousand population) results in a decrease in the number of cholecystectomies per thousand population performed.

Where the variables $HPOP_{kt}$ and $SPOP_{kt}$ are entered separately, there was little price response within the four procedures and relatively little substitution would be expected on the basis of the short-run elasticities in Table 6.4. The short-run own-price elasticities derived from (6.2) are of the form

$$\frac{\partial Q_i}{\partial P_i} \quad \frac{P_i}{Q_i}$$

$$= \frac{-1}{Q_i} \quad [Q_i \; - \phi_i \; HPOP - \gamma_i \; SPOP \; - \theta_i \; Q_{i,t-1}] \tag{6.3}$$

For the ordinary least squares estimates in Table 6.3, the general form for the short-run cross-price elasticities is

$$\frac{\partial Q_i}{\partial P_j} \quad \frac{P_j}{Q_i} = \beta_{ij} \; (P_j/P_i) \; (1/Q_i) \tag{6.4}$$

With respect to P_{okt}, separate cross-price elasticities are calculated for each province, the general formula being

$$\frac{\partial Q_i}{\partial P_o} \quad \frac{P_o}{Q_i} = \frac{1}{Q_i} \quad \delta_{ik} \; [D_k \cdot (P_o/P_i)_k] \tag{6.5}$$

where i=1,4 denotes the i^{th} equation and k = 1,10 denotes the province; the mean values of the variables, specific to each province, are substituted in equation (6.5).

The general form for the short-run elasticity with respect to hospital beds reported in Table 6.3 is given by equation (6.6).

$$\frac{\partial Q_i}{\partial HPOP} \quad \frac{HPOP}{Q_i} = \phi_i \; \frac{HPOP}{Q_i} \tag{6.6}$$

TABLE 6.4

SHORT-RUN SUPPLY ELASTICITIES DERIVED FROM ORDINARY LEAST SQUARES

(GENERALIZED LEONFIEF FORM I) - CANADA - (1973 - 1981)

	HM	IH	CH	HT
P_{HM}	.07	.03	-.00	.26
P_{IH}	-.16	-.11	.07	.15
P_{CH}	-.05	.01	-.46	-.26
P_{HT}	.27	.06	.39	-.00
NFP_O	-.42	-.07	-.10	-.11
PEP_O	-.20	.10	-.06	-.06
NSP_O	-.23	-.01	.09	-.06
NBP_O	.00	.03	.03	-.10
QUP_O	.06	.03	.03	-.09
ONP_O	-.08	.09	-.00	-.19
MAP_O	-.25	.03	-.04	-.37
SAP_O	-.27	-.10	-.03	-.55
ALP_O	-.22	-.06	-.01	-.13
BCP_O	-.03	.03	.06	-.09
HPOP	.44	.22	-.08	.32
SPOP	.10	.16	-.30	.12

Note: Based on Table 6.3 parameter estimates, with mean values assumed for the variables.

Equation (6.7) gives the general form for elasticities with respect to surgical specialists.

$$\frac{\partial Q_i}{\partial SPOP} \frac{SPOP}{Q_i} = \gamma_i \frac{SPOP}{Q_i} \tag{6.7}$$

The general form for the long-run own-price elasticity is

$$\frac{\partial Qi}{\partial P_i} \frac{P_i}{Q_i} = \frac{-1}{Q_i} [\, Q_i - \frac{\phi_i}{1-\theta_i} HPOP - \frac{\gamma_i}{1-\theta_i} SPOP \,] \tag{6.8}$$

For the remaining elasticity formulas, the general form for the corresponding long-run elasticity is equivalent to the short-run elasticity, divided by $(1 - \theta_i)$. (The long-run cross-price elasticities with respect to the composite price index are not specific to each province, since provincial estimates for θ_i could not be obtained.)

The relevant long-run elasticities, presented in Table 6.5 are greater in absolute value than the short-run elasticities. Support for substitution in production with this functional form is found with regard to P_{okt}, rather than within the four elective procedures themselves. Elastic cross-price substitution results are estimated for the long-run with respect to HT and the price of other procedures in Saskatchewan. Inelastic results are reported for all other provinces. While the short-run and long-run elasticities for $HPOP_{kt}$ and $SPOP_{kt}$ were less than one for HM, IH and HT, the results for CH were negative in the short run, while the output per thousand population for CH was elastic with respect to $SPOP_{kt}$ in the long run.

TABLE 6.5

LONG-RUN SUPPLY ELASTICITIES DERIVED FROM ORDINARY LEAST SQUARES

(GENERALIZED LEONFIEF FORM I) - CANADA - (1973 - 1981)

	HM	IH	CH	HT
P_{HM}	.14	.05	- .01	.59
P_{IH}	-.33	-.23	.61	.33
P_{CH}	-.10	.03	-4.30	- .58
P_{HT}	.56	.13	3.36	- .01
NFP_O	-.89	-.13	- .86	- .24
PEP_O	-.41	.20	- .50	- .14
NSP_O	-.48	-.02	.74	- .13
NBP_O	.00	.05	.23	- .22
QUP_O	.12	.06	.28	- .20
ONP_O	-.17	.18	- .02	- .42
MAP_O	-.54	.06	- .32	- .82
SAP_O	-.58	-.20	- .23	-1.22
ALP_O	-.46	-.13	- .12	- .30
BCP_O	-.06	.06	.54	- .21
HPOP	.92	.44	- .73	.72
SPOP	.22	.33	-2.57	.27

Note: Based on Table 6.3 parameter estimates and Table 6.4 calculations.

An alternative method of entering hospital beds per thousand population and surgical specialists per thousand population is multiplicatively as (HPOP.SPOP). To be consistent with the form of the generalized Leontief variable profit function, the square roots of both variables are entered. With A_{kt}, denoting ($HPOP^{\frac{1}{2}}.SPOP^{\frac{1}{2}}$), constant returns to scale are imposed with regard to these independent variables[2]. Such a specification recognizes the need for both a surgical specialist and a hospital bed for the patient undergoing elective surgery. The general form of the supply equation for estimation is

$$Q_{ikt} = \beta_{ii} A_{kt} + \sum_{j=1}^{4} \beta_{ij} (P_j/P_i)_{kt} + \sum_{k=1}^{10} \delta_{ik} D_k (P_o/P_i)_{kt} + \theta_i Q_{ik,t-1} + \varepsilon_{ikt} \quad (i \neq j) \qquad (6.9)$$

The results for the second form are presented in Table 6.6 and the corresponding elasticity calculations are presented in Tables 6.7 and 6.8.

The general form of the short-run own-price elasticity formula is

$$\frac{\partial Q_i}{\partial P_i} \frac{P_i}{Q_i} = \frac{-1}{Q_i} [Q_i - \beta_{ii} A - \theta_i Q_{i,t-1}] \qquad (6.10)$$

where the mean values of Q_i, A and $Q_{i,t-1}$ are substituted in (6.10). The general form for the short-run cross-price elasticity is

$$\frac{\partial Q_i}{\partial P_j} \frac{P_j}{Q_i} = \beta_{ij} (P_j/P_i) (1/Q_i) \qquad (6.11)$$

TABLE 6.6

OUTPUT SUPPLY PARAMETERS ESTIMATED BY ORDINARY LEAST SQUARES. (GENERALIZED LEONTIEF FORM II) - CANADA - (1973-1981)

VARIABLE	HAEMORROIDECTOMY		INGUINAL HERNIORRAPHY		CHOLECYSTECTOMY		HYSTERECTOMY	
$(P_j/P_i)_{kt}$	- .12	(- .87)	.09	(.24)	- .04	(- .03)	1.96	(2.26)
	- .04	(- .49)	.03	(.12)	.34	(.34)	1.13	(1.47)
$j \neq i$	.18	(2.50)	.18	(1.05)	1.87	(3.67)	- .94	(-1.95)
$D_{NF}.B$	- .61	(-1.91)	- .41	(- .54)	-1.09	(- .44)	-1.78	(-1.02)
$D_{PE}.B$	- .43	(-1.36)	.96	(1.36)	-1.10	(- .47)	-1.65	(- .96)
$D_{NS}.B$	- .66	(-1.85)	- .14	(- .16)	2.04	(.78)	-2.41	(-1.39)
$D_{NB}.B$	- .07	(- .20)	.26	(.29)	.80	(.29)	-2.74	(-1.40)
$D_{QU}.B$	- .08	(- .24)	.20	(.24)	- .41	(- .17)	-3.08	(-1.62)
$D_{ON}.B$	- .47	(-1.26)	.93	(1.07)	- .78	(- .27)	-4.75	(-2.16)
$D_{MA}.B$	- .88	(-2.18)	.18	(.19)	-1.39	(- .46)	-7.45	(-2.82)
$D_{SA}.B$	- .63	(-1.60)	- .77	(- .78)	.35	(.11)	-7.37	(-2.86)
$D_{AL}.B$	- .76	(-1.86)	- .74	(- .75)	- .27	(- .07)	-4.29	(-1.92)
$D_{BC}.B$	- .31	(- .91)	.15	(.19)	.20	(.08)	-3.24	(-1.69)
A_{kt}	.46	(3.16)	.89	(2.23)	-1.24	(-2.97)	1.46	(3.47)
$Q_{ik,t-1}$	.52	(4.86)	.51	(4.66)	.90	(15.27)	.54	(5.33)

Notes:
1. P_i refers to the own-price in each equation. B denotes $(P_o/P_i)_{kt}$ attached to the provincial dummy variables, as in Table 6.3.
2. The intercept has been suppressed to retain consistency with the Generalized Leontief form.
3. Hospital beds per thousand population ($HPOP_{kt}$) and Surgical Specialists per thousand population ($SPOP_{kt}$) are entered multiplicatively, with constant returns to scale imposed. A_{kt} denotes $(HPOP)^{\frac{1}{2}} . (SPOP)^{\frac{1}{2}}$.
4. The critical t-statistic for a two-tailed test at the 10 per cent level of significance, with 15 degrees of freedom is 1.753.

Again, with respect to P_{okt}, separate cross-price elasticities are calculated for each province, the general formula being

$$\frac{\partial Q_i}{\partial P_o} \frac{P_o}{Q_i} = \frac{1}{Q_{ik}} \delta_{ik} [D_k . (P_o/P_i)_k] \tag{6.12}$$

Since constant returns to scale are imposed, the general form for the elasticity with respect to hospital beds and with respect to surgical specialists is given by equation (6.13).

$$\frac{\partial Q_i}{\partial HPOP} \frac{HPOP}{Q_i} = \frac{1}{2} \frac{1}{Q_i} [\beta_{ii} A] = \frac{\partial Q_i}{\partial SPOP} \frac{SPOP}{Q_i} \tag{6.13}$$

The long-run own-price elasticity for this specification is

$$\frac{\partial Q_i}{\partial P_i} \frac{P_i}{Q_i} = \frac{-1}{Q_i} [Q_i - \frac{\beta_{ii}}{1 - \theta_i} A] \tag{6.14}$$

(The remaining long-run elasticities are the short-run elasticities, divided by $(1 - \theta_i)$, with θ_i not specific to each province.)

As indicated by the parameter estimates in Table 6.6 and the elasticity estimates in Tables 6.7 and 6.8, entering $HPOP_{kt}$ and $SPOP_{kt}$ in this multiplicative manner strengthened the responsiveness to changes in the price of other procedures (P_{okt}), especially in equations 1 (CH) and 4 (HT). The expected negative sign is obtained for the relative price term (P_{CH}/P_{HT}) and the result is statistically significant. Although some evidence for substitution is found for the other operations, it did not predominate within the subset of the four elective procedures.

TABLE 6.7

SHORT-RUN SUPPLY ELASTICITIES DERIVED FROM ORDINARY LEAST SQUARES (GENERALIZED LEONTIEF FORM II) - CANADA - (1973 - 1981)

	HM	IH	CH	HT
P_{HM}	.08	.02	-.00	.24
P_{IH}	- .15	-.13	.05	.18
P_{CH}	- .09	.01	-.47	-.26
P_{HT}	.34	.09	.43	.03
NFP_O	- .42	-.07	-.08	-.11
PEP_O	- .23	.09	-.05	-.09
NSP_O	- .28	-.01	.09	-.10
NBP_O	- .02	.02	.04	-.14
QUP_O	- .02	.02	-.02	-.16
ONP_O	- .17	.08	-.04	-.27
MAP_O	- .35	.02	-.06	-.45
SAP_O	- .24	-.08	.02	-.55
ALP_O	- .27	-.07	-.01	-.17
BCP_O	- .12	.02	.01	-.17
HPOP	.28	.18	-.20	.24
SPOP	.28	.18	-.20	.24

Note: Based on Table 6.6 parameter estimates, with mean values assumed for the variables.

TABLE 6.8

LONG-RUN SUPPLY ELASTICITIES DERIVED FROM ORDINARY LEAST SQUARES

(GENERALIZED LEONTIEF FORM II) - CANADA - (1973 - 1981)

	HM	IH	CH	HT
P_{HM}	.15	.05	- .04	.53
P_{IH}	- .30	-.27	.49	.39
P_{CH}	- .18	.03	-5.01	- .56
P_{HT}	.71	.18	4.24	.07
NFP_O	- .86	-.14	- .75	- .25
PEP_O	- .48	-.19	- .54	- .19
NSP_O	- .58	-.03	.87	- .21
NBP_O	- .05	.05	.37	- .31
QUP_O	- .05	.04	- .16	- .35
ONP_O	- .35	.16	.39	- .58
MAP_O	- .72	.03	- .60	- .99
SAP_O	- .50	-.17	.19	-1.19
ALP_O	- .55	-.15	- .08	- .37
BCP_O	- .25	.03	.11	- .38
HPOP	.58	.37	-2.00	.53
SPOP	.58	.37	-2.00	.53

Note: Based on Table 6.6 parameter estimates and Table 6.7 calculations.

The negative signs for the estimated price coefficients indicate some evidence of substitution in supply. Positive signs (except CH) were obtained for the elasticities with respect to A_{kt}. Long-run elasticities are greater than short-run elasticities indicating the greater responsiveness in supply over time[3].

The ordinary least squares estimation is based on the classical linear regression model. One of the assumptions of this model is that the independent variables are uncorrelated with each other. Where such correlation exists, multicollinearity is said to exist. The presence of multicollinearity was suggested in the results for the ordinary least squares regressions by high R^2's and low t-statistics. Since additional data were not available, econometric corrections for multicollinearity were tested. Two possible methods are ridge regression and principal components.

The ridge regression technique involves specification of a parameter c with $0 < c < 1$ such that lower mean square errors are obtained from the regression compared with the ordinary least squares results (see Johnston, 1984). (Ordinary least squares results are obtained when $c = 0$). A major problem with the technique is that the interpretation of the estimators is not known since the technique "consists of an arbitrary numerical adjustment."[4] Since the sampling distribution is unknown, hypothesis testing cannot be carried out.

With principal components, composite variables are formed which are linear combinations of the explanatory variables. The results are sensitive to the unit of measurement. Less information is used to obtain the estimates compared with OLS estimation of the original variables and the resulting coefficients may not have an economically meaningful interpretation. Hence, statistical tests may not be valid.

Econometric techniques to adjust for multicollinearity have their drawbacks; there are difficulties in the interpretation of the resulting estimates. However, the ultimate reason for rejecting them is that much economic data, particularly health data, are inherently multicollinear. Thus eliminating such collinearity by arbitrary numerical means is not desirable. A potentially preferable approach involves the use of alternative functional forms; they might provide a better explanation of the supply response in any case.

Another assumption of the classical linear regression model is that the error terms are not correlated with each other and they have uniform variance. Where this is not the case, as often occurs with time series and cross-section ecomomic data, the disturbances are said to be non-spherical or autocorrelated. Using the OLS estimator in such a situation will result in parameter estimates that are not efficient; that is, they do not have minimum variance[5]. The generalized least squares (GLS) estimator has minimum variance, and is therefor a more efficient estimator than the OLS estimator. Systems estimation methods yield more efficient estimates in that any correlations between the error terms, ε_{ikt}, are taken into account.

In order to reach a better understanding of the supply responses to price changes, a system of revenue share equations based on the translog function is estimated. This work is reported in the next section.

6.3 TRANSLOG REVENUE SHARE SYSTEM

The translog revenue function adapted from Appelbaum and Harris (1977) is as follows

$$\ln R = \sum_{i=o}^{4} \alpha_i \ln P_i + \tfrac{1}{2} \sum_{i=o}^{4} \sum_{j=o}^{4} \beta_{ij} \ln P_i \ln P_j$$

$$+ \sum_{j=o}^{4} \phi_j \ln P_j \ln H + \sum_{j=o}^{4} \gamma_j \ln P_j \ln S$$

$$+ \tau_{hs} \ln H \ln S + \tfrac{1}{2} \tau_{hh} (\ln H)^2$$

$$+ \tfrac{1}{2} \tau_{ss} (\ln S)^2 \qquad (6.15)$$

where P_i, P_j refer to output prices and H and S refer to the fixed factors, hospital beds and surgical specialists respectively.

The revenue share equations corresponding to this translog revenue function are

$$J_i = \alpha_i + \sum_{j=o}^{4} \beta_{ij} \ln P_j + \phi_i \ln H + \gamma_i \ln S \qquad (6.16)$$

where J_i denotes the revenue share for the i^{th} operation, $(P_i Q_i)/R$.

The τ coefficients cannot be estimated in the share equations. To allow for dynamic adjustments, lagged revenue shares are included as independent variables. Since the preliminary estimates suggested that the composite price index showed relatively great response, dummy variables representing the provinces were attached to P_{okt}, and hence entered the slope terms, rather than as intercepts.

With these adjustments, the general form of the revenue share equation, specified in a stochastic framework, is

$$J_{ikt} = \alpha_i + \sum_{j=1}^{4} \beta_{ij} \ln P_{ijkt} + \sum_{k=1}^{10} \delta_{ik} D_k \ln P_{okt}$$

$$+ \phi_i \, HPOP_{kt} + \gamma_i \, SPOP_{Kt} + \theta_i \, J_{ik,t-1} + \varepsilon_{ikt} \qquad (6.17)$$

Since the shares must sum to one, only four of the five equations need to be estimated. The fifth equation (other procedures) was omitted. The four revenue share equations were estimated as a system. Pooled cross-section and time series Canadian data for the period 1973 to 1981 were used to obtain the estimates. For each equation the restrictions $\sum\beta_{ij} + \sum\delta_{ik} = 0$ and $\phi_i + \gamma_i = 0$ are imposed. Since the cross-equation symmetry conditions of $\beta_{ij} = \beta_{ji}$ for the share equations were tested and not rejected at the 10 per cent level of significance, these conditions were imposed in obtaining the parameter estimates.

The estimated coefficients for the revenue share equations are given in Table 6.9. By and large, they are not very encouraging. Only one own-price coefficient had the expected positive sign. Although 8 of the 12 cross-price coefficients were negative, indicating substitution, none were statistically significant at the ten per cent level. There is

TABLE 6.9

PARAMETER ESTIMATES OF SHARE EQUATIONS - CANADA - (1973-1981)

VARIABLE	HAEMORROIDECTOMY		INGUINAL HERNIORRAPHY		CHOLECYSTECTOMY		HYSTERECTOMY	
Ln P_{HMkt}	-.0490	(-3.14)	-.0102	(-1.53)	.0063	(1.35)	.0071	(.98)
Ln P_{IHkt}	-.0102	(-1.53)	.0232	(3.14)	-.0035	(- .75)	-.0104	(-1.60)
Ln P_{CHkt}	.0063	(1.35)	-.0035	(- .75)	-.0015	(- .30)	-.0067	(-1.38)
Ln P_{HTkt}	.0071	(.98)	-.0104	(-1.60)	-.0067	(-1.38)	-.0092	(-1.05)
D_{NF} Ln P_{okt}	-.0029	(-1.64)	.0002	(.20)	-.0007	(-1.19)	.0010	(1.12)
D_{PE} Ln P_{okt}	-.0033	(-1.66)	.0003	(.34)	-.0013	(-1.92)	-.0007	(- .79)
D_{NS} Ln P_{okt}	-.0077	(-2.54)	.0005	(.43)	-.0021	(-2.77)	.0051	(3.27)
D_{NB} Ln P_{okt}	-.0034	(-1.74)	.0039	(4.69)	.0012	(1.97)	.0038	(2.75)
D_{QU} Ln P_{okt}	.0077	(2.49)	.0029	(2.30)	.0034	(4.21)	.0006	(.66)
D_{ON} Ln P_{okt}	.0016	(.73)	.0029	(2.44)	.0008	(1.13)	-.0006	(- .69)
D_{MA} Ln P_{okt}	.0031	(1.59)	.0044	(3.36)	.0006	(.77)	.0012	(1.43)
D_{SA} Ln P_{okt}	-.0030	(-1.05)	.0019	(1.46)	.0001	(.14)	-.0011	(- .66)
D_{AL} Ln P_{okt}	.0028	(1.12)	.0047	(3.55)	.0009	(1.30)	-.0001	(- .10)
D_{BC} Ln P_{okt}	.0020	(.85)	.0023	(2.18)	.0008	(1.17)	.0008	(1.03)
$HPOP_{kt}$	.0100	(1.72)	-.0039	(-2.08)	.0001	(.08)	.0007	(.35)
$SPOP_{kt}$	-.0100	(-1.72)	.0039	(2.08)	-.0001	(- .08)	-.0007	(- .35)
$J_{ik,t-1}$	.5426	(5.68)	.2612	(2.56)	-.1497	(-1.40)	.3920	(4.33)
Constant	.2353	(2.61)	.0810	(2.91)	.0513	(2.74)	.1077	(3.34)

Notes:
1. The critical t-statistic at the 10 per cent level of significance with 17 degrees of freedom is 1.74.
2. Cross-equation symmetry, $\beta_{ij} = \beta_{ji}$, has been imposed for the relative price terms.

little evidence of substitution with regard to the price of all other procedures. The lagged dependent variables have the expected positive sign and are statistically significant, except for cholecystectomies. (The latter's estimated coefficient, although negative, is not statistically significant.) The coefficients on hospital beds and surgical specialists have the correct signs (opposite to each other due to the homogeneity restrictions imposed) and are statistically significant only for inguinal herniorraphies. However, the effects of price changes on revenue shares were modest for the four operations, as indicated by the magnitude of the coefficients; little indication of substitution could be found at this aggregate level from the translog specification of the share equations.

The supply elasticities with respect to price changes are closely related to the substitution possibilities. An indication of supply responses can be obtained from the calculation of supply elasticities associated with the revenue share equations; the method is analogous to that for calculating estimates of substitution possibilities among inputs based on the cost share equations derived from the cost function (see Brown, Caves and Christensen, 1975).

In general form, the own-price elasticities are given by

$$\eta_{ii} = \frac{\beta_{ii} + J_i (J_i - 1)}{J_i} \qquad (6.18)$$

The cross-price supply elasticities for the translog form are

$$\eta_{ij} = \frac{\beta_{ij} + J_i J_j}{J_i} \qquad (i \neq j)$$

(6.19)

The elasticities with respect to hospital beds is given by the general form

$$\eta_{Hi} = \frac{\phi_i + J_i(J_i - 1)}{J_i}$$

(6.20)

Elasticities with respect to surgical specialists are obtained by substituting γ_i instead of ϕ_i in equation (6.20).

Short-run output elasticities based on estimates in Table 6.9 are presented in Table 6.10. It is not possible with this functional form to obtain information with regard to the supply responses of the other procedures. Also, given the adding up constraints, it is not possible to consider responses within provinces.

One should be cautious in the interpretation of the elasticities since the underlying parameter estimates on which they are based are so ill-determined. For this reason, long-run elasticities were not tabulated. Difficulties with gaining access to more disaggregated data preclude more detailed specifications based on the translog form. It cannot be determined from the data set whether starting directly with the production function would yield estimates with lower standard errors and hence higher t-statistics[6].

TABLE 6.10

SHORT-RUN ELASTICITIES DERIVED

FROM REVENUE SHARE ESTIMATES - CANADA - (1973-1981)

	HM	IH	CH	HT
P_{HM}	- 1.08	.06	.53	.52
P_{IH}	.03	- .64	- .11	.01
P_{CH}	.05	- .02	- 1.06	- .30
P_{HT}	.06	- .10	- .34	- 1.42
P_o	6.03	13.03	54.96	48.79
HPOP	- .76	- .96	- .98	- .95
SPOP	- .87	- .87	- .99	- 1.01

Note: Based on Table 6.9 parameter estimates, with mean values assumed for the variables.
Due to the unsatisfactory results, long-run elasticities are not presented.

An alternative functional form to consider is the generalized Leontief profit function derived by Diewert (1973) and adapted by Woodland (1977). The preliminary OLS results suggest that the generalized Leontief form of the derived supply equations is promising. This functional form also assumes profit maximizing behaviour on the part of agents and satisfies the assumptions of duality theory, as did the translog form.

6.4 GENERALIZED LEONTIEF VARIABLE PROFIT FUNCTION

The general form of the variable profit function, adapted from Woodland (1977), is

$$R(P; H,S) = H^{\frac{1}{2}} S^{\frac{1}{2}} \sum_i \sum_j \beta_{ij} (P_i P_j)^{\frac{1}{2}} \qquad (6.21)$$

where P denotes the vector of benefit rates, P_i denotes the benefit rate of the ith procedure, H denotes hospital beds, S denotes surgical specialists, and β_{ij} is the parameter of the term involving cross-products of the prices of procedures i and j.

Constant returns to scale are imposed on the function (see Diewert, 1973, p. 302). The supply equations derived from the variable profit function are

$$q_i = H^{\frac{1}{2}} S^{\frac{1}{2}} \sum_{j=1}^{5} \beta_{ij} (P_j/P_i)^{\frac{1}{2}} \qquad (6.22)$$

Dividing both sides of (6.22) by population gives supply per thousand population, Q_i, as the dependent variable. Entering population scales the data to account for different populations within each province.

In this functional form, price effects are not independent of the availability of both surgical specialists and hospital beds, as indicated by attaching A_{kt} (denoting $HPOP^{\frac{1}{2}}$ $SPOP^{\frac{1}{2}}$) to the relative price terms. Lagged dependent variables are retained and the dummy variables representing the provinces were attached to $(P_o/P_i)_{kt}$. (Other variables are as denoted in section 6.2B.)

The final form for the estimation of the supply equations is

$$Q_{ikt} = \beta_{ii} A_{kt} + \sum_{j=1}^{4} \beta_{ij} A_{kt} (P_j/P_i)_{kt}^{\frac{1}{2}}$$

$$+ \sum_{k=1}^{10} \delta_{ik} A_{kt} D_k (P_o/P_i)_{kt}^{\frac{1}{2}}$$

$$+ \theta_i Q_{ik,t-1} + \varepsilon_{ikt} \qquad (i \neq j) \qquad (6.23)$$

The four supply equations were estimated as a system of seemingly unrelated regressions (SURE), a procedure due to Zellner[7]. Table 6.11 contains the estimated coefficients for the supply equations.

An increase in the benefit rate of HT relative to CH resulted in an increase in the number of HT performed, indicating support for supply substitution. The results for the cross-price terms within the four procedures exhibited some limited support for substitution in the output of the four elective surgical procedures. Strong support was found for substitution in all four equations with regard to changes in the price of other procedures, as indicatd by the negative coefficients for the relative price $(P_o/P_i)_{kt}$. (An increase in P_i means a decrease in $(P_o/P_i)_{kt}$ and a resulting substitution toward Q_{ikt}. For example, an increase in P_{HT} in Alberta (AL) results in a decrease in P_o/P_{HT} and an increase of 4.00 in the number of hysterectomies (HT) per thousand

TABLE 6.11

GENERALIZED LEONTIEF PROFIT FUNCTION: PARAMETER ESTIMATES CANADA - (1973-1981)

VARIABLE	HAEMORROIDECTOMY		INGUINAL HERNIORRAPHY		CHOLECYSTECTOMY		HYSTERECTOMY	
	- .31	(-1.36)	- .04	(- .07)	.89	(.77)	2.12	(3.05)
$A_{kt}(P_j/P_i)_{kt}^{\frac{1}{2}}$	- .11	(- .65)	- .13	(- .33)	.77	(.63)	1.42	(1.89)
	.51	(3.95)	.20	(.76)	2.79	(4.10)	-1.96	(-3.41)
$A_{kt}\ D_{NF}\cdot G$	- .85	(-2.69)	- .73	(-1.06)	-2.80	(-1.58)	-2.83	(-2.81)
$A_{kt}\ D_{PE}\cdot G$	- .67	(-2.16)	.77	(.12)	-2.60	(-1.54)	-2.87	(-2.90)
$A_{kt}\ D_{NS}\cdot G$	- .74	(-2.41)	- .86	(-1.29)	-3.01	(-1.76)	-3.20	(-3.24)
$A_{kt}\ D_{NB}\cdot G$	- .39	(-1.20)	- .68	(- .95)	-2.85	(-1.58)	-3.33	(-3.15)
$A_{kt}\ D_{QU}\cdot G$	- .40	(-1.27)	- .49	(- .71)	-2.73	(-1.57)	-3.43	(-3.30)
$A_{kt}\ D_{ON}\cdot G$	- .67	(-2.00)	- .11	(- .16)	-3.38	(-1.81)	-4.09	(-3.70)
$A_{kt}\ D_{MA}\cdot G$	- .93	(-2.71)	- .57	(- .78)	-3.67	(-1.92)	-5.09	(-4.35)
$A_{kt}\ D_{SA}\cdot G$	- .75	(-2.21)	-1.16	(-1.55)	-3.44	(-1.80)	-4.89	(-4.21)
$A_{kt}\ D_{AL}\cdot G$	- .83	(-2.41)	-1.09	(-1.44)	-3.68	(-1.90)	-4.00	(-3.55)
$A_{kt}\ D_{BC}\cdot G$	- .56	(-1.76)	- .60	(- .88)	-3.12	(-1.75)	-3.44	(-3.32)
A_{kt}	.77	(3.24)	1.93	(3.31)	-1.74	(-1.89)	2.50	(4.85)
$Q_{ik,t-1}$	.34	(4.09)	.36	(3.90)	.72	(14.73)	.54	(7.72)

Notes:
1. A_{kt} denotes $(HPOP)^{\frac{1}{2}}\ .\ (SPOP)^{\frac{1}{2}}$ and G denotes $(P_o/P_i)_{kt}^{\frac{1}{2}}$.
2. In each equation, the own-price, P_i, appears in the denominator, and P_j, $j \neq i, 0$, appears in the numerator.
3. The intercept is suppressed to allow estimation of the coefficient, β_{ii}.
4. The critical t-statistic using a two-tailed test at the 10 per cent level of significance, with 14 degrees of freedom is 1.76 (t-statistics in brackets).

population.) The coefficients were statistically significant in most provinces, especially for CH and HT. The estimates for the price coefficients suggest that most substitution opportunities occur between the four procedures and all other procedures as represented by the weighted price index, rather than within the subset of the four surgical procedures selected.

The variable A_{kt} indicates the effect of changes in hospital beds and surgical specialists. The estimated effect of a one-unit increase in both hospital beds and surgical specialists per thousand population is an increase of .77 for HM, of 1.93 for IH, and of 2.50 for HT. An (unexpected) decrease is recorded for CH. There are too few observations available to compare the effects of changes in hospital beds and surgical specialists across provinces. The estimated coefficient of the lagged dependent variable has the expected positive sign, and is statistically significant in all four supply equations. Its value is less than one in all cases.

Elasticities derived from the parameter estimates in Table 6.11 are listed in Tables 6.12 and 6.13. All short-run elasticities (Table 6.12) are less than the long-run elasticities (Table 6.13).

The general form of the own-price elasticity is

$$\frac{\partial Q_i}{\partial P_i} \frac{P_i}{Q_i} = - \frac{1}{2} \frac{1}{Q_i} [Q_i - \theta_i Q_{i,t-1} - \beta_{ii} A] \qquad (6.24)$$

Three of the four short-run own-price supply elasticities have the anticipated positive sign, and are inelastic[8].

TABLE 6.12

SHORT-RUN SUPPLY ELASTICITIES DERIVED FROM THE GENERALIZED LEONTIEF VARIABLE PROFIT FUNCTION

CANADA - (1973 - 1981)

	HM	IH	CH	HT
P_{HM}	.14	-.01	.10	.25
P_{IH}	-.22	.06	.09	.19
P_{CH}	-.10	-.03	-.41	-.34
P_{HT}	.45	.05	.04	.19
NFP_O	-.05	-.01	-.02	-.02
PEP_O	-.03	-.00	-.02	-.02
NSP_O	-.04	-.01	-.02	-.02
NBP_O	-.01	-.01	-.02	-.02
QUP_O	-.01	-.01	-.02	-.02
ONP_O	-.02	-.00	-.02	-.03
MAP_O	-.04	-.01	-.03	-.05
SAP_O	-.03	-.02	-.03	-.05
ALP_O	-.03	-.01	-.02	-.03
BCP_O	-.02	-.01	-.03	-.03
HPOP and SPOP	.33	.32	.13	.23

Note: Based on Table 6.11 parameter estimates, with mean values assumed for the variables.

TABLE 6.13

LONG-RUN SUPPLY ELASTICITIES DERIVED FROM THE GENERALIZED LEONTIEF VARIABLE PROFIT FUNCTION CANADA - (1973 - 1981)

	HM	IH	CH	HT
P_{HM}	.21	-.01	.35	.54
P_{IH}	-.33	.10	.34	.41
P_{CH}	-.16	-.05	-1.52	-.74
P_{HT}	.69	.08	.16	.41
NFP_O	-.07	-.02	- .08	-.04
PEP_O	-.04	.00	- .06	-.04
NSP_O	-.06	-.02	- .08	-.05
NBP_O	-.02	-.01	- .07	-.05
QUP_O	-.02	-.01	- .06	-.05
ONP_O	-.04	-.00	- .09	-.07
MAP_O	-.06	-.01	- .09	-.11
SAP_O	-.05	-.02	- .11	-.12
ALP_O	-.05	-.02	- .09	-.06
BCP_O	-.03	-.01	- .09	-.06
HPOP and SPOP	.50	.50	.50	.50

Note: Based on Table 6.11 parameter estimates and Table 6.12 calculations.

The long-run own-price elasticity for the functional form specified in equation (6.23) is given by equation (6.25).

$$\frac{\partial Q_i}{\partial P_i} \frac{P_i}{Q_i} = - \frac{1}{2} \cdot \frac{1}{Q_i} \left[Q_i - \frac{\beta_{ii}}{1 - \theta_i} A \right] \qquad (6.25)$$

The general form of the short-run cross-price elasticities is

$$\frac{\partial Q_i}{\partial P_j} \frac{P_j}{Q_i} = \frac{1}{2} \frac{1}{Q_i} \beta_{ij} A (P_j/P_i)^{\frac{1}{2}} \qquad (6.26)$$

All other long-run elasticities are given by dividing the short-run elasticitiy by $(1 - \theta_i)$. Again, with respect to P_{okt}, the short-run cross-price elasticities are specific for each province. (For the long-run elasticity, the coefficient, θ_i is not specific to each province.) The general form is

$$\frac{\partial Q_i}{\partial P_o} \frac{P_o}{Q_i} = \frac{1}{2} \frac{1}{Q_{ik}} \delta_{ik} [A_k D_k (P_o/P_i)_k^{\frac{1}{2}}] \qquad (6.27)$$

Strong evidence of substitution occurs with respect to changes in P_{okt}, as seen by the negative signs in Tables 6.12 and 6.13. However, the small number of estimated negative cross-price elasticities suggest that, at least for the time period considered, there is little substitution in production within the subset of four elective surgical procedures selected.

The short-run elasticities for hospital beds are of the same general form as for surgical specialists due to the constant returns to scale assumption. The general form is

$$\frac{\partial Q_i}{\partial HPOP} \frac{HPOP}{Q_i} = \frac{1}{2} \frac{1}{Q_i} [Q_i - \theta_i Q_{i,t-1}] = \frac{\partial Q_i}{\partial SPOP} \frac{SPOP}{Q_i} \qquad (6.28)$$

All estimates with respect to hospital beds and surgical specialists have the expected positive sign and generally suggest an inelastic response to changes in available facilities. The long-run supply elasticities of 0.50 attained for the four operations with respect to hospital beds and surgical specialists are consistent with the constant returns to scale imposed on the functional form.

6.5 SUMMARY

It has been suggested that physician response to marginal revenue might help to explain the higher variations in the rates of elective surgical procedures relative to non-elective ones. A model based on the standard maximizing behaviour assumed in neoclassical production theory predicts that the composition of aggregate output would contain more of the relatively higher priced elective procedures after an increase in their relative benefit rates. Individual physicians, it is argued, could be viewed as price takers with regard to relative benefit rates. To ascertain the effect of relative price changes on supply, a multiproduct specification of the functional form is required[9], with the emphasis on the supply incentives provided by the own-price and prices of other procedures that compete for the time of the physician.

Within the four elective procedures selected, little evidence of responsiveness to changes in relative prices is found. However, evidence of substitution of these elective procedures with all other items covered by the weighted price index was found. That is, for all four procedures, substitution in response to a change in P_{okt} relative to P_{ikt} is indicated. The estimated effects are statistically significant for

CH and HT, and in most provinces for HM. Where (unexpected) positive signs occur, the estimates are generally not statistically significant. These results are consistent with other studies relating to extra-billing studies; most procedures subject to extra-billing are included under the category represented by the composite price index for all other procedures. Office visits and confinements are cited in the literature as often being subject to extra-billing; such procedures would be more readily substituted when relative prices change.

Other factors in addition to relative prices also determine supply. Measures of the availability of hospital beds and surgical specialists are included in the estimated functional form, so that the price responses are not estimated independently of net capacity constraints. With respect to the effect of capacity constraints separately, denoted by A_{kt}, three of the four equations have the expected positive sign; the exception is the equation for cholecystectomies (CH). Budget constraints and a stronger auditing function may also explain the low price response within the four elective surgical procedures. The results suggest that, given the technological constraints, it is easier for surgeons to substitute among the operations and the procedures in the category covered by the weighted price index, rather than within the four procedures selected.

Lagged dependent variables have the expected positive signs and are statistically significant in all equations. Long-run elasticities are higher (in absolute value) than the short-run elasticities, confirming the expected greater responsiveness over time. However, only a one-year lag was incorporated and further price responsiveness may only become evident when a data period greater than nine years (1973 to 1981 inclusive) is considered.

A major conclusion is that there is little price response at the aggregate level. This may be due in part to the limited opportunities for a large price response in surgery, as compared with office visits and consultations. Surgical procedures, particularly those considered elective, also appear to be more subject to the constraints imposed by hospital operating budgets.

In drawing conclusions from the study, the inherent multicollinearity and the consequent limitations of the data set arising from the restriction of the time period to nine years must be borne in mind. Subject to these qualifications, the major determinants of the supply of elective surgery are the availability of qualified surgical personnel and of hospital facilities. Overall, there is some evidence of substitution in response to changes in the price of all other procedures. There is, however, a limited response within the four elective surgical procedures considered. While price appears to play an important role, the substitution in production that affects aggregate output is not on the basis of price alone.

NOTES TO CHAPTER SIX

1 The ordinary least squares results in Section 6.2 were estimated by the Minitab statistical package. Systems estimations in Sections 6.3 and 6.4 were conducted with the Shazam econometric package (See White, 1978).

2 When increasing returns to scale were imposed on the function, no material differences in the price coefficients resulted.

3 The ordinary least squares estimates for supply equations are similar whether estimated for Canada or for various provincial groupings. When the elasticities were calculated with the means for different provincial groupings, the results did not differ materially from those for Canada as a whole.

4 See Johnston (1984), p.252.

5 In a study comparing the efficiency of OLS, GLS and ML (Maximum Likelihood) estimators, Woodland (1979) found that while the GLS estimator was only marginally less efficient than the ML estimator, the OLS estimator was found to be 16 per cent less efficient in that higher standard errors were obtained for the latter.

6 See Notes to Chapter Four, #2. Berndt and Savin (1975) find that if the restrictions implied by the adding up property of the share equations are not imposed, the ML parameter estimates are no longer independent of the equation deleted.

7 Johnston (1984) states that " (The) choice of which of the ..... equations to drop.... is an arbitrary one. The SURE estimates are not invariant to the choice of equation to drop. However, iteration of the SURE technique will produce parameter estimates that converge to the ML parameter estimates, which are unique and independent of the equation omitted" (p.340). Data constraints, however, prevent the estimation of the supply (and share) equation for all other procedures.

8 A system of supply equations for the Atlantic provinces was estimated using the SURE technique. The results were also inelastic with respect to prices and to the variables denoting the key fixed factors (see Waples, 1983).

9 Since the results are consistent across all functional forms tested, the discussion here focuses on the generalized Leontief estimates presented in Section 6.4. The unsatisfactory results obtained for the translog form preclude comparisons of functional forms.

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

7.1 OVERVIEW

The concern with excessive numbers of elective surgical procedures being performed, as expressed in the clinical literature, is not new, but government involvement in the financing of health care and stricter budget constraints have made the cost of medical services subject to greater scrutiny. Inefficiencies in output mix will result in higher costs, and it is suggested that some inefficiencies in health care stem from over-servicing. Comparisons of international and intranational surgical rates have found that differences in morbidity patterns do not provide satisfactory explanations of such variations, especially in the case of elective surgical procedures. Other possible explanations of the phenomenon have been sought, a major one being the differences across jurisdictions in financial incentives. The most obvious financial incentive is the set of prices for the provision of medical services, as incorporated in the medical fee structure.

Universal public health insurance has reduced the financial constraints for the consumer of health care services in Canada. In practice, procedures, at least those beyond the initial visit, are determined mainly by physicians. This is especially the case for surgical procedures. Thus the physician's role in allocating hospital and other health care resources is crucial, and attention should, therefore, be focused on the determinants of the supplier decision if the market for health care services is to be properly understood, and if costs are to be controlled. The neoclassical theory of the firm based on standard maximizing behavioural assumptions is appropriate in modelling responses to price changes. In order to determine the changes in supply in response to relative price changes, the prices of more than one type of operation must be included as independent variables in the derived supply equations.

Government cost control in Canada has been based mainly on global budgeting principles. The overall increases in the budgets available for the provision of medical services in each province separately are agreed upon after negotiations between governments and representatives of the provincial medical associations. Any subsequent increases in benefit rates for the various procedures are negotiated within the medical profession itself, again separately for each province. Thus there are variations both over time and among provinces in the relative prices for different surgical procedures.

A multiproduct specification of output is realistic; physicians, both at the individual level and in the aggregate, produce not just one service but a range of services. The importance of output mix in explaining variations in costs has been affirmed in various studies of hospital costs, based on both the case mix approach and on estimates of multiproduct cost functions. It is possible that physicians respond to differential benefit rates by changing their output mix as relative benefit rates change, switching to those procedures that yield a higher income per unit time. Thus, if the multiproduct nature of their production is not recognized the cost increases that result from changes in service mix that are induced by changes in the fee structure cannot be modelled. Yet there is evidence of the allocative effect of the fee structure in various studies.

A review of the fee structure as it relates to the four elective procedures considered and also to a weighted index representing the price of all other surgical and nonsurgical procedures suggests that there might have been sufficient variation in the fee structure across Canada and over time for the period of the study to produce a change in output mix. The purpose of this study has been to model, in an aggregated multiproduct context, the supply of selected elective surgical procedures in order to obtain a measure of the supply response to changes in relative benefit rates.

Thus, substitution in production is the focus of this research, rather than substitution in consumption. That is, the attempt has been to measure the extent of movement along the physician production possibility frontier in response to changing relative benefit rates. While relative prices are an obvious factor to consider, resource constraints imposed on and by hospitals also play a major role in the decision to perform elective operations. Key resource inputs determine the position of the production possibility frontier. Since the four operations are in the major surgery category, the availability of surgical facilities and of hospital beds is critical. However, lack of data on surgical facilities precluded their use as a technological constraint, and the availability of hospital beds alone was considered as a reasonable indicator of overall resource availability. The services of surgical specialists are also required jointly with the availability of hospital beds and key support staff. However, high collinearity within the data precluded using variables representing the support staff and so the number of surgical specialists alone was included as an independent variable representing personnel requirements. The generalized Leontief form recognizes the joint requirement that both a surgical specialist and a hospital bed be available, in that both input variables are entered multiplicatively.

In addition to the constraints imposed by data availability (a common problem in economic research, and particularly in health economics research) are the constraints imposed by the econometric estimation methods. For example, the number of parameters which must be estimated in the multiproduct specification increases with the number of products (elective surgical procedures in this case). For this reason, we have focused on only four specific procedures, and treated all other procedures as one composite service. The price of the composite service is represented by a weighted price index, with the weights based on the relative frequency of procedures which claim the physician's time. Also, while price taking behaviour is a reasonable assumption under Canada's public health insurance scheme, it has the additional virtue of conserving degrees of freedom in the econometric estimation, as has the application of Hotelling's lemma to derive the supply equations.

Although the preliminary ordinary least squares estimates suggested inelastic supply price responses, some evidence of price substitution was found and the results were consistent across all the specifications tested. Insufficient observations were available to estimate the four supply equations as a system for each province separately. However, results for provincial groupings were similar to those for Canada as a whole. The estimated coefficients associated with the capacity constraints had positive signs for three of the four operations. An unexpected negative sign was found for CH. Based on the appropriate tests, lagged dependent variables and dummy variables representing the provinces were found to be statistically significant and hence they were incorporated into the functional forms tested. However, some functional forms may have severe limitations for empirical work, especially in the multiproduct context.

In econometric estimates of production function parameters, it is desirable that the functional form not constrain the (input) substitution elasticities to be constant; rather it should be "flexible" in allowing varying substitution possibilities and returns to scale. The development of flexible functional forms also facilitated econometric estimation of supply parameters. Providing that functions exhibit well-behaved mathematical characteristics consistent with the postulates of the economic theory of the firm, the technological characteristics of a production function can be represented equally well by its dual profit or cost function. However, data limitations precluded starting with a cost function, so the supply equations are derived from profit functions by applying Hotelling's lemma.

Some of the flexible functional forms are not "self-dual" in the sense that a production function and its dual profit or cost function do not belong to the same family. Hence the starting point of deriving supply equations may affect the estimated coefficients. Also, the results obtained when starting with a cost function may differ from those obtained with a profit function, but due to data limitations, it was not possible to make such comparisons.

7.2 CONCLUSIONS FROM THE STUDY

After consideration and estimation of alternative specifications, supply equations based on the generalized Leontief variable profit function were favoured. Such equations were derived for the four elective surgical procedures on which this study focuses. The number of hospital beds and of surgeons available is incorporated in the variable profit function, and this feature enhances its promise for modelling supply responses. All four supply equations were estimated as a system of seemingly unrelated regressions (SURE). Supply elasticities with respect to prices and fixed factors were derived.

Evidence was found in support of the view that physicians allocate their time partly in response to changes in the price of elective procedures relative to other procedures, but not in response to price changes within the four elective surgical procedures themselves. Since the opportunity for a major response in terms of changes in aggregate output is within the four elective surgical procedures, it appears that resource constraints and the effects of budgetary restrictions on key resources in the health system have a greater impact than relative prices in determining the output at the aggregate level. Furthermore, the coefficients of the lagged dependent variables suggest also that price is not the only factor. Instead, an inertia model of adjustment seems to apply; what doctors did last year affects what they do this year, independently of prices.

The effects of extra-billing have not been estimated explicitly, but it is expected that doing so would not yield a significantly different measure of price responsiveness for surgical specialists. Payments made to opted-out physicians billing above tariff do not constitute a major portion of payments in any province, and various studies indicate that surgical services are not as subject to extra-tariffs as are office visits, confinements and eye examinations. Instead, the indications of substitution between the four elective surgical procedures and all other procedures are consistent with there being more opportunity for substitution in production to take place in the area of those services subjected to extra-billing.

While prices have been found to be secondary to technological factors in determining aggregate output, they remain important within the health care system. Prices do affect physicians' decisions and, because of government involvement in health care expenditure negotiations, are a continuing source of controversy. Nonetheless, at the aggregate level, the measured price responses reported here provide evidence that surgeons do not substitute extensively in production between the four elective procedures strictly on the basis of price.

The evidence of limited price responsiveness might result in part from the particular limitations of the available data set. Especially when overall health expenditures are subject to budgetary controls elective surgical procedures would possibly be given low priority of access to hospital facilities, and this might be reflected as inelastic price responses.

The apparent lack of price responsiveness might result also from the level of aggregation of the data used. Further work at a more disaggregated level might reveal a greater response in supply, as indicated by measures of price elasticities, but this must await the availability of suitable data.

BIBLIOGRAPHY

Abel-Smith, Brian (1979): Value for Money in Health Services: A Comparative Study. (London, Heinemann).

------- (1983): "Economic Efficiency in Health Care Delivery," in Improving Cost-Effectiveness in Health Care (International Social Security Association Studies and Research, Number 19).

Appelbaum, E. and R. Harris (1977): "Estimating Technology in an Intertemporal Framework: A Neo-Austrian Approach," Review of Economics and Statistics 54:161-170.

Berndt, Ernst R. and N. Eugene Savin (1975): "Estimation and Hypothesis Testing in Singular Equation Systems with Autoregressive Disturbances," Econometrica 43:937-957.

Brown, Malcolm C. (1983): National Health Insurance in Canada and Australia: A Comparative Political Economy Analysis (Canberra:- The Australian National University, Health Economics Research Unit).

Brown, Murray A., and Vernon A. Hicks (1983): Billing Above Tariff by Physicians in the Absence of Opting-Out Penalties. (Paper presented at the Second Canadian Conference on Health Economics, Regina, Saskatchewan.)

Brown, Randall, S., Douglas W. Caves and Laurits R. Christensen (1975): Modelling the Structure of Production with a Joint Cost Function, Social Systems Research Institute, University of Wisconsin - Madison, Workshop Series #7521.

Burgess, David F. (1975): "Duality Theory and Pitfalls in the Specification of Technologies," Journal of Econometrics 3:105-121.

Cageorge, Sandra M., Leslie L. Roos and Rudy Danzinger (1981): "Gallbladder Operations: A Population Based Analysis," Medical Care 19:510-525.

Canada, Health and Welfare Canada (1984): National Health Expenditures in Canada, 1970-1982 (Ottawa, Policy Planning and Information Branch, Health Information Division).

Canada, Health and Welfare Canada: Canada Health Manpower Inventory (Ottawa, Policy Planning and Information Branch, Health Information Division; Various years, 1972-1981).

Canada, Health and Welfare Canada (1983): Active Civilian Physicians (Ottawa, Policy Planning and Information Branch, Health Information Division; unpublished).

------ (1982): National Health Expenditures in Canada: Medical Care-Statistical Supplement to the Annual Report, 1979-1980. (Ottawa, Policy Planning and Information Branch, Health Information Division; unpublished)

------ (1976): Instructions and Definitions for the Annual Return of Health Care Facilities (Part One).(Ottawa, Policy Planning and Information Branch, Health Information Division; unpublished)

Canada, Statistics Canada: Hospital Statistics, various years, 1970--1975. (Ottawa, Cat. no. 83-232)

------ (1982): Preliminary Annual Hospital Statistics (Ottawa, Health Division).

Clute, R. (1963): The General Practioner (Toronto: University of Toronto Press).

Cowing, Thomas G., and Alphonse G. Holtmann (1983): "Multiproduct Short-Run Hospital Cost Functions: Empirical Evidence and Policy Implications from Cross Section Data," Southern Economic Journal 49:637-653.

Coyte, Peter C. (1985): "The Market for Medical Services and Physicians: An Application of Hedonic Price Theory," Canadian Journal of Economics 18:377-394.

Denny, Michael (1974): "The Relationship between Functional Forms for the Production System," Canadian Journal of Economics 7:21-31.

Diewert, W.E. (1971): "An Application of the Shephard Duality Theorem: A Generalized Leontief Production Function," Journal of Political Economy 79:481-507.

------ (1973): "Functional Forms for Profit and Transformation Functions," Journal of Economic Theory 6:284-316.

------ (1974): "Applications of Duality Theory," in M. Intrilligator and D. Kendrick, (eds.), Frontiers of Quantitative Economics, Vol. II (Amsterdam: North Holland).

Dorland's Pocket Medical Dictionary (22nd edition) (Philadelphia, W.B. Saunders and Company).

Evans, Robert G.(1974): "Supplier-Induced Demand: Some Empirical Evidence and Implications," in M. Perlman (ed.), The Economics of Health and Medical Care (London: MacMillan).

------ (1984): Strained Mercy: The Economics of Canadian Health Care (Toronto: Butterworths).

Feldstein, Martin F. (1974): "Econometric Studies in Health Economics," in M. Intriligator and D. Kendrick (eds), Frontiers of Quantitative Economics, vol 1. (Amsterdam, North Holland).

Fuss, M., D. McFadden and Y. Mundlak (1978): "A Survey of Functional Forms in the Economic Analysis of Production," in M. Fuss and D. McFadden (eds.), Production Economics: A Dual Approach to Theory and Applications (Amsterdam, North Holland).

Harrison's Principles of Internal Medicine (1983): various authors. (10th edition)

Hastings, J.E.F., F. Mott, D. Hewitt and A.T. Barclay (1970): "An Interim Report on the Sault Ste. Marie Study: A Comparison of Personal Health Services Utilization," Canadian Journal of Public Health 61:289-96.

Johnston, J. (1984): Econometric Methods (3rd Ed. New York: McGraw-Hill).

LeClair, Maurice (1975): "The Canadian Health Care System" in S. Andreopoulos (ed.) National Health Insurance: Can We Learn from Canada? (New York: John Wiley).

Le Riche, W. Harding and Mabel L. Halliday (1983): "The Toronto Study of Alberta Surgical Rates, 1978," Department of Preventive Medicine and Biostatistics, Faculty of Medicine, University of Toronto (unpublished).

Lewis, Charles (1969): "Variations in the Incidence of Surgery," New England Journal of Medicine, 281: 880-884.

McFadden, Daniel (1978): "Cost, Revenue and Profit Functions," in Production Economics: A Dual Approach to Theory and Applications. M. Fuss and D. McFadden (eds.), (Amsterdam: North Holland).

Newhouse,Joseph P. (1978): The Economics of Medical Care: A Policy Perspective. (Reading, Mass. Addison-Wesley Publishing Company).

Pauly, M.V. (1978): "Is Medical Care Different?" in R.D. Luke and J.C. Bauer (eds.), Issues in Health Economics (Rockville, Maryland: Aspen Systems Corporation).

------ (1980): Doctors and their Workshops: Economic Models of Physician Behaviour (Chicago: The University of Chicago Press).

Roos, Leslie L. Jr. (1983): "Supply, Workload and Utilization: A Population-Based Analysis of Surgery in Rural Manitoba," American Journal of Public Health 73:414-421.

Roos,Leslie L. Jr. and Noralou P. Roos (1983): "Assessing Existing Technologies: The Manitoba Study of Common Surgical Procedures," Medical Care 21:454-462.

Roos, Noralou P. and Leslie L. Roos Jr. (1982): "Surgical Rate Variations: Do They Reflect the Health or Socioeconomic Characteristics of the Population?" Medical Care 20:945-958.

Rutkow, I.M. and C.D. Zuidema (1978): "Unnecessary Surgery: An Update." Surgery 84:671-78.

Shephard, R.W. (1970): Theory of Costs and the Production Function (Princeton, NJ: Princeton University Press).

Taylor, Malcolm G. (1978): Health Insurance and Canadian Public Policy (Montreal: McGill-Queen's University Press).

Tatchell, P.M. (1983): Measuring Hospital Output: A Review of the Service Mix and Case Mix Approaches (Canberra, The Australian National University, Health Economics Research Unit, Reprint Number 11).

Uzawa,H. (1964): " Duality Principles in the Theory of Cost and Production," International Economic Review 5: 1-24.

Vayda, Eugene (1973): "A Comparison of Surgical Rates in Canada and England and Wales," New England Journal of Medicine 289:1224--1229.

------ (1977): "Prepaid Group Practice under Universal Health Insurance in Canada," Medical Care 15:382-389.

------, Mary Morison and Gary Anderson (1976): "Surgical Rates in the Canadian Provinces, 1968-1972," Canadian Journal of Surgery 19:235-242.

Waples, M.Jane (1983): "Testing for Price Response in Surgical Output Mix in Atlantic Canada: A Multiproduct Approach." Atlantic Canada Economics Association Papers 12:89-98.

Wennberg, John, and Alan Gittelsohn (1982): "Variations in Medical Care Among Small Areas," Scientific American 246:120-134.

White, K.J. (1978): "A General Computer Program for Econometric Methods - SHAZAM," Econometrica 46:239-240.

Woodland, A.D. (1977): "Estimation of a Variable Profit Function and of Planning Price Functions for Canadian Manufacturing," Canadian Journal of Economics 10:355-377.

-------- (1979): "Stochastic Specification and the Estimation of Share Equations," Journal of Econometrics 10:361-383.