INNOVATION AND HEALTH EXPENDITURES: SOME EMPIRICAL RESULTS FOR A DIAGNOSTIC TECHNOLOGY*

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There is debate on whether the adoption of new medical technologies has been a contributing factor to rising health expenditures. This literature is critically reviewed and another approach is advocated. This alternative approach rests on the distinction between product and process innovations. It is argued that the relationship between innovations and health expenditures can be illuminated, for process innovations, by determining if they are used as substitutes. The empirical results provide no indication that alternative technologies for diagnosing diseases/conditions of the upper gastrointestinal tract have been utilised by Australian medical practitioners, operating on a fee-for-service basis, as substitutes. The study provides new empirical support for the view that medical innovations contribute to rising health expenditures.

Keywords: health expenditure, medical technology, substitutes, complements, diagnostic tests

INTRODUCTION

Various countries have now recognised medical technology as a 'problem' and have begun to develop policies of one kind or another to address it.[1,2] The 'technology problem' in health services has a number of major dimensions. First, there is the issue of efficacy and/or safety. Banta has argued that "some technologies have been in widespread use and later have been shown to lack efficacy."[3] Furthermore there is a question of safety.[4] Examples of innovations that were adopted before efficacy was demonstrated include gastric freezing,[5] the computed tomography (CT) scanner[6] and, more recently, magnetic resonance imaging (MRI).[7]

Second, there are various ethical and legal issues that are raised by technological change in medicine. Some of these issues, such as the definition of 'death',[8] the ownership of cadaver organs[9] and the

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conditions under which surgery can take place[10] have arisen from medical and surgical developments that have enabled organ transplantation. The most recent scientific-medical development that has directed societal attention to ethical and/or legal dimensions of medical technology is *in vitro* fertilisation.[11]

The third major dimension is the relationship between technology and the diffusion of innovations and expenditures for health services. It is well known that through time rising expenditures for health care, as a proportion of gross domestic product and/or in absolute terms, characterise many economies.[12] In examining the relationship between medical technology and health costs, economists have adopted a number of different approaches.

This paper is concerned only with this third issue of the relationship between technology/innovation and health expenditures. The various economic approaches that have been applied will be described and evaluated in the next section. It is then argued that the previous literature has not taken account of the distinction between product and process innovations, a categorisation that has generally been applied in economic studies of innovations. With respect to process innovations it is argued that the sign of the cross-price elasticity of demand can be used to determine if a particular process innovation has substituted for an existing technology. Whether process innovations substitute for existing technologies clearly has implications for health expenditures.

VARIOUS ECONOMIC APPROACHES

Econometric Model Building

Economists have adopted as number of different approaches to determine if there is a connection between medical innovation and health expenditures. First, Feldstein[13] has approached the question by use of an econometric model with fifteen equations in five groups, *viz,* the demand for hospital care, the demand for insurance, the determination of inputs and quality, price adjustment and the expansion of capacity. Feldstein's view is that ". . .while technological change generally results in lower unit costs in most industries, technological change in hospitals leads to an increase in quality and a higher unit cost."[14]

Feldstein's results point to technology as a factor which contributes to increasing costs in hospitals. However, in his framework technology is a passive factor in that the central role is given to the effects of rising health insurance coverage: insurance is an enabling factor that allows hospital management to alter the mix of services provided and the new medical services introduced are more expensive as they incorporate new technology. Thus Feldstein's emphasis in explaining rising hospital costs is on changing demand factors.

Feldstein's empirical work was undertaken on aggregate data from United States (US) hospitals. This focus on a particular institution, the hospital, takes no account of the non-hospital sector and his measures of hospital output (admissions and average length of stay) are not disaggregated into more homogeneous groups of patients in terms of purpose, e.g., diagnosis, etc. In other words, aggregate data take no account of the multi-product nature of hospital outputs.

Three Residual Approaches

Another type of aggregate analysis, which can be called *the residual approach,* has been applied to determine the effect of technology. There are three relevant literatures. The first approach is concerned with analysing time series *total health expenditures* rather than the emphasis on hospital costs in Feldstein's work. There are two relevant studies in the *genre,* both relating to US experience, by Fuchs[15] and Mushkin and Landefeld.[16] Essentially the technique involves fitting data to a model which is considered to include the relevant variables, such as changes in prices, population and the ageing of the population, third-party payments, income, etc., that can explain changes in total health expenditures. That part of changing health expenditures which is *not* accounted for by the explanatory variables, the residual, is said to be the effect of technology. A positive residual can be interpreted to indicate that technology has increased health expenditures whereas a negative residual can be interpreted to mean that technology has reduced health expenditures. In the period 1947-1967, Fuchs[17] found that the residual was small, but positive, whereas Mushkin and Landefeld[18] found a small negative residual for the period 1930-1970. Thus these two studies have come to opposite conclusions on the effect of technology on health expenditures, Mushkin and Landefeld's study indicating that health expenditures would have been larger if there had been no technological change and Fuchs' study indicating that technology had increased health expenditures.

A second residual approach has been applied. Davis[19] has undertaken a pooled cross-section and time-series multiple regression analysis on US non-profit private hospitals which submitted audited cost data in the period 1962 to 1968. Her concern was to determine the relative importance of demand factors, case-mix, wage increases and technology in determining hospital costs. Given that there were no direct measures of technology available, Davis included a time variable "to capture the residual effect of increases in average costs over time"[20] and this time trend is assumed to measure the effects of technology. By comparing adjusted R^2 values when various explanatory variables are dropped from the equations Davis concludes "The combination of all factors, therefore, is required for a complete view of the determinants of average expenses."[21] Her results indicated that the demand variables, case-mix variables, average earnings of hospital employees and "shifts upward over time", i.e., technology, accounted for 45 per cent, 7 per cent, 10 per cent and 38 per cent of increased hospital expenses respectively.

Given this procedure the 38 per cent of hospital costs that is not explained by demand and supply variables (the unexplained 38 per cent representing a two per cent annual increase in hospital costs per admission), is taken to be the effect of technology. Although Davis admits that the time trend "may include not only changes in technology but basic shifts in patient, physician or hospital behaviour", she gives no reasons for making this assumption. If this assumption, *viz*, that the effect of technology is captured by the time trend in the regression equations, is not accepted (and there are reasons to believe that it is not acceptable as suggested by Davis), then little significance can be attached to the results. Although it could be argued that this study puts an upper limit on the effect of technology there is no way to determine the relative importance of 'technology' and the 'other factors' that have contributed to the time trend. Whether 'technology' represents one per cent or 37 per cent is relatively important. There is no way to unscramble this omelette.

A third residual approach can be described as the 'excess inflation' approach. This approach focuses on the concept 'average cost per patient day' in hospitals. By reference to accounting data it can be determined to what extent changes in the prices of non-labour hospital inputs and wages for labour services can explain the change in cost per patient day. For example, in 1976 hospital costs per patient per day in the US rose by 14.7 per cent and input prices and wages rose by 8.3 per cent, leaving 6.4 per cent unexplained.[22] In other words 56 per cent of the rise in cost could be attributed to wage and price increases and the remainder had to be attributed to 'all other factors.' A similar approach has been taken by Feldstein and Taylor.[23]

The most important criticism of such studies is that the implicit concept of hospital output being employed is the patient day. For this to be a meaningful measure of hospital output it is necessary to assume that each day of patients' stays involves the same output. This ignores factors such as the variability of input intensity during a patient's stay and, more importantly, how inputs vary between patients depending on the nature of the case. In other words the multi-product nature of hospital output is ignored.[24]

Attention is now directed to a more disaggregated approach to assessing the connection between technology and health expenditures.

The Impact of Technology on Selected Illnesses

Scitovsky has been analysing data on the cost-of-illness for specified diseases/conditions at the Palo Alto Medical Clinic in California since 1951.[25] Her work is based on the notion that when a person has a specific disease or condition, various inputs such as medical practitioner services, hospital bed days, tests, pharmaceuticals, etc. are combined to provide a *treatment* for the defined disease or condition. Data on the number and prices of services employed in the treatment of the specified illnesses/conditions are obtained in various years in current prices. Then the services used in the early year are priced at the prices prevailing in the later year. By comparing these different costs the *net* effect of changes in treatment can be determined: "if average costs in the later year are higher than those in the base year in the later year's prices, the net effect of changes in treatment has been cost-raising, if they are lower, changes have been cost-saving."[26] Given sufficiently detailed data it is possible to determine the role of an innovation and/or technology in changing the use of inputs.

Scitovsky's work has shown that technology has contributed to the rise in the treatment costs of specified illnesses. In the period 1951 to 1971, the main factor was the steady rise in the use of ancillary services such as laboratory tests and X-rays.[27] In the period 1971 to 1981 Scitovsky has found that technology has also increased costs, but it is no longer the application of the 'standard' tests and procedures that is causing the increase in costs. "This cost-of-illness study suggests that. . .the rate of increase in the use of ancillary services appears to have slowed down but that several new and expensive technologies came into use, which raised costs substantially. This finding is in sharp contrast to the earlier studies, which showed that the increased use of little-ticket technologies was the main technologic change raising health care costs."[28] This finding has been verified by other studies.[29]

Analysis of Supplier Interests

Although there are various literatures on the supply side addressing such issues as cost comparisons of Health Maintenance Organisations (HMOs) and fee-for-service medicine[30] and the incentive structures that are operating within health insurance carriers such as Blue Cross-Blue Shield,[31] by far the most important research findings relate to the supplier-induced demand hypothesis which Enthoven[32] has described as "Perhaps the most interesting and significant empirical finding about provider behaviour in the insured fee-for-service context."

Fuchs and Kramer[33] estimated an econometric model of the market for the services of medical practitioners and concluded that "supply factors, technology, and number of physicians appear to be of decisive importance in determining the utilization of and expenditures for physicians services. . .Indeed, we find that the elasticities of demand with respect to income, price and insurance are all small relative to the direct effect of the number of physicians on demand."[34] Since then Fuchs has undertaken a study on surgeons[35] and similar studies have been undertaken in Australia[36] and Belgium[37] as well as numerous studies in North America. For recent surveys and comment on this much debated issue see Willensky and Rossiter, Stano and Reinhardt.[38]

Evans' argument is that medical practitioners have two roles, *viz,* that of the patient's *agent* ". . .providing expert direction or assistance in the interpretation of the patient's health status, the identification of the capacity of current medical technology to improve that status, and the skilled application of that technology"[39] and that of a *supplier* ". . .of a particular class of services [and] whose income and work satisfaction are related to the volume of services he supplies and the price he receives for them."[40] The reason for the agency relationship that characterises the health sector is an informational asymmetry between consumers and producers. According to Evans this can lead to a situation in which there is *a conflict of interest* between the medical practitioner and the consumer ". . .particularly if medical practice is organised on an entrepreneurial fee-for-service basis. Such a setting creates strong economic incentives for the physician to overemphasise the supply of his own services to the exclusion of substitutes and to bias the patient's 'choice' of service towards those which yield the highest net revenue per time unit. . ."[41]

The public policy implications of this hypothesis are profound in terms of the efficacy of increasing the supply of medical practitioners to reduce health care expenditures, the efficacy of higher fees via deductibles and co-insurance rates to restrain utilisation and hence expenditures, and the view that market reforms are appropriate to replace government regulations in the health sector. The heated debate in the literature on this issue is explicable when it is realised that this hypothesis, involving interdependence between suppliers and consumers rather than independence, implies that no normative significance can be attached to the outcome in such a 'market'.

Although not all of these studies concerning supplier behaviour have been directed to technology or innovation *per se,* the point is that there are financial incentives at work that influence the behaviour of medical practitioners. Even if the supplier-induced demand hypothesis is not accepted the evidence on the lower costs associated with HMOs compared to fee-for-service medicine, the influence of the medical profession on health insurance carriers, and the structure of incentives to providers is sufficiently strong to place provider behaviour close to the top of the research agenda when considering increasing health expenditures. In this context medical services involving new technologies are simply to be regarded as a particular sub-set of all medical procedures and subject to the same forces.

AN ALTERNATIVE PROPOSAL

It is clear from the previous discussion that all approaches taken by economists are subject to criticism of one kind or another: all studies are flawed. In addition there is no agreement or common definition of technology employed by the various authors. However, nearly all studies conclude that technology in the health sector is a 'problem'. Leaving aside questions of efficacy, safety, ethics, etc., is this concern justified? Assuming that there is a positive relationship between health technology and health expenditures, does it matter? Why should it be of concern for public policy?

It can be argued that innovations fall into two categories, *viz, process* innovations and *product* innovations. Blaug defines the former as "novel ways of making old goods" and the latter as "old ways of making novelties."[42] Although there are difficulties with these distinctions in practice, e.g., one firm's product innovation may be another firm's process innovation[43] and a process innovation may cause a change in output or product, the definitions are useful, albeit arbitrary. Blaug argues, in fact, that ". . .the refusal to discriminate between product and process innovations would close the subject of technical progress to further analysis."[44] Katsoulacos[45] has employed these distinctions with considerable effect in the theoretical literature on the effect of new technology on employment.

These distinctions can be seen in the health field. The various activities that comprise the *in vitro* fertilisation program can be regarded as a product innovation, i.e., they involve the creation of a new product or service. In like manner the advent of renal dialysis in the 1960s can be described as a product innovation: prior to this medical procedure there was no treatment available for people with end-stage renal disease. Kidney transplantation, on the other hand, can be regarded as a process innovation, as it is an alternative treatment for dialysis.[46] The pharmaceutical cimetidine, and other histamine H_2- receptor antagonists, can also be regarded as process innovations, substituting for surgical procedures, for people subject to peptic ulcer.[47] Similarly, extra-corporeal shock wave lithotripsy is a substitute for surgery to remove kidney stones. Process innovations also occur in diagnostic medicine: fibre optic endoscopy is an alternative to barium meal radiology for diagnosing disease/conditions of the upper gastrointestinal tract.[48]

These examples also indicate Blaug's point that process innovations may well change the nature existing procedures. People may not be indifferent to taking cimetidine three times a day and undergoing surgery. In like manner fibre optic endoscopy involves, for most diseases/conditions, statistically significant increases in diagnostic accuracy over barium meal radiology.[49] In addition to these output considerations there are cost differences that are relevant. The welfare implications of perfect and imperfect substitutes in the health sector have been discussed, in a Hicksian framework, elsewhere.[50]

Of their very nature process innovations are substitutes for an already existing technique: a process innovation provides an alternative way of doing something. The examples mentioned previously, *viz,* the alternative ways of treating end-stage renal disease, cimetidine and ulcer surgery, lithotripsy and kidney surgery, and fibre optic endoscopy and barium meal radiology, all have this characteristic.

There are two ways in which process innovations could cause a rise in health expenditures. First, the new process may be more costly to undertake and when utilised in place of the previous technique, health expenditures will rise. If the new process did not have associated with it a change in the mix of outputs associated with the alternatives, e.g., less pain, improved success rate, etc. then there would be cause for concern. Second, the process innovation, rather than displacing the already existing technique, may be utilised in conjunction with the first technique. In other words the alternatives are being used in clinical practice as complements rather than as substitutes. If this were to happen than the process innovation clearly would create an issue of public policy concern.

Since the Hicks-Allen revolution in demand theory there has been unanimity, with the exception of Samuelson's money metric measure,[51] that substitutes and complements could be empirically determined by the sign of the cross-price elasticity of demand, where this is understood to be calculated by reference to compensated price changes. Commodities are said to be net (Hicksian) substitutes if the cross-price elasticity is greater than zero and net complements if the cross-price elasticity is less than zero. If the cross-price elasticity equals zero then the commodities are said to be unrelated or independent.[52] Thus the sign of the cross-price elasticity of demand can be used to determine whether commodities are substitutes or complements. The effect of process innovations on health expenditures, viewed in this perspective of substitutability, can thus be determined empirically. If the sign of the cross-price elasticity is negative, this would indicate that the alternatives are being utilised as complements. In other words, medical practitioners are utilising *both* procedures and hence health expenditures will rise as a result of the process innovation being treated as a complement to the already existing procedure.

This procedure has been undertaken on Australian fee-for-service data for alterntive technologies of diagnosing diseases/conditions of the upper gastrointestinal tract.

THE TECHNOLOGIES AND THE DATA

The most important means of diagnosis of the upper gastrointestinal tract, until the 1960s, was barium meal radiology. However in 1958 a fully flexible fibre optic gastroscope was demonstrated.[53] The major physical characteristic of fibre optic endoscopes is flexibility. Modern instruments have facilities for removing tissue specimens, using biopsy forceps, cytology brushes and snare loops. Photographic and/or cinematic records can be made of the conditions observed.[53]

It has been shown elsewhere[55] that the outputs of diagnostic tests in medicine are two pieces of (probabilistically measured) information about disease status, *viz,* the predictive value of a positive test ressult and the predictive value of a negative test result. Furthermore, statistical tests of inference have shown that there are significant differences between barium meal radiology and fibre optic endoscopy in terms of both measures of diagnostic accuracy. Given that both technologies provide diagnostic information of the same kind about disease status of the upper gastrointestinal tract, there are *a priori* grounds for believing that they are economic substitutes and hence will be characterised by positive cross-price elasticities of demand.

The data for this study relate to these two diagnostic services provided to persons holding Health Care Cards by Australian medical practitioners operating on a fee-for-service basis. On 1 September 1981 the Commonwealth Government, as part of a number of changes to health insurance arrangements in Australia, introduced Health Care Cards for 'special need' persons and their dependants. There were three groups entitled to these cards. First, migrants and refugees for their first six months in Australia; second, persons in receipt of unemployment and special benefit; and third, persons with low incomes, as defined by the Commonwealth Government. No premium was payable for these entitlements: the scheme was funded from general Commonwealth revenue. The Commonwealth Government paid 85 per cent of the schedule fee for any medical service provided on a fee-for-service basis to persons holding Health Care Cards.

The data on Health Care Cardholders are a particular sub-set of the Health Insurance Collection, a computer-based record system of all medical services provided on a fee-for-service basis, for which a Commonwealth subsidy is paid. This collection is described in detail elsewhere.[56]

The observations for this study are quarterly state data for the six Australian states for the period from the December quarter of 1981 to the December quarter of 1983. Generally this scheme ceased operation on 1 February 1984 with the introduction of Medicare. Given that the data apply to nine quarters for the six states, estimating equations on nine time-series observations or six cross-section observations means that there will be few degress of freedom, thus giving little confidence in the statistical results. Furthermore, there were nine observations for quantity of endoscopic procedures (eight in Tasmania and one in Western Australia) in the data that were zero, thus giving only 45 observations in total, if the data set were pooled.

It was decided to combine the data set for Health Care Cardholders with a data set relating to persons covered by the Pensioner Medical Service. This latter data set, for the six Australian states, applies to the period from the June quarter 1979 to the December quarter 1983. Thus there are 19 time-series observations and when pooled, the data set has 114 observations. The combined data set thus comprises 159 observations. Summary statistics, and sources for the data, are indicated in the Appendix.

There is no *a priori* reason to expect that the underlying demand for these diagnostic procedures would be different between these two groups of Commonwealth beneficiaries. However statistical tests can be conducted on this combined data set to determine if this expectation is confirmed. This involves the applciation of dummy variables for all the coefficients in the estimated equations. In order to test for statistical differences in the demand for the medical procedures between the two groups, an additive dummy as well as multiplicative ones for the variables were included in the estimating equations.

Initially the Pensioner Medical Service data set was used to determine the most important independent variables. The independent variables were own-price, cross-price, income, supply of medical practitioners, a time trend and quarterly dummies. Few quarterly dummies were significant, the own-price coefficients were uniformly negative as expected, few income coefficients were signigicantly different from zero and some medical workforce measures were positive and significant. The cross-price coefficients were either zero, indicating unrelated products, or negative, indicating complements. No positive cross-price coefficients were obtained. There were few differences when linear and double-log equations were estimated.

Stepwise regression was applied to the pooled data set for pensioners, the only variable forced in being own-price. Generally the stepwise regression indicated that own-price, cross-price, and medical practitioner supply variables were the most important. The most interesting result was that when cross-price was entered, the coefficients were uniformly negative, indicating complementarity. This analysis suggested the following explanatory variables as the most important: own-price, cross-price, and medical practitioner supply. Income was also included on theoretical grounds. Since the double-log specification leads to the convenient interpretation of the coefficients, i.e., the coefficients are elasticities, Table 1 presents the double-log results estimated on the data for both Health Care Cardholders and pensioners. There are no substantive differences between the double-log and the linear specifications.

Although the barium meal equation performs a little better than the fibre optic endoscopy equation (in terms of adjusted R^2 and the standard error of the estimate), both equations have significant F-statistics at the five per cent level. Thus there is reason to believe that the explanatory variables, as a group, explain the variations in the dependent variables. Examination of the correlation matrix indicated that multicollinearity was not a problem. Although the calculated Durbin-Watson statistic indicated the presence of serial correlation in the data, the pooling of these two data sets (of different size) means that the Durbin-Watson statistic is not meaningful in this context.

Both own-price elasticities have expected (negative) signs and are significant at the five per cent level. The two income elasticities are positive but not significant. This is not a surprising result as both measures of income, the standard age pension and the married unemployment benefit, have little variation as they are indexed by the Commonwealth Government. The number of radiologists per 10,000 people covered, the variable to test for supplier-induced demand in the radiology equation, is not significantly different from zero. However, the supply variable in the endoscopy equation is positive and has a smaller standard error than the corresponding coefficient in the radiology equation.

Given the focus of this paper, attention is directed to the sign of the cross-price elasticity of demand. The *a priori* expectation is that this elasticity will be positive, given that the technologies are substitutes. Both elasticities are negative, although not significantly different from zero at the five per cent level. However, the cross-price elasticity in the endoscopy equation would be significant if a less severe level of statistical significance were used.

These elasticities, being effectively zero at the five per cent level, indicate that the diagnostic procedures being analysed here are unrelated or independent. There is no empirical support for these alternative technologies being utilised as economic substitutes in medical practice. If a less severe level of statistical significance is invoked, then it could be concluded from the endoscopy equation that barium meal radiology and fibre optic endoscopy are complements.

TABLE 1

OLS Regression Results of Demand Equations Using a Double-Log Specification on Pooled Data for Pensioners and Health Care Cardholders

	Barium Meal Radiology	Fibre Optic Endoscopy
Elasticities:		
Own-price	–0.25*	–0.44*
	(–4.15)	(–2.09)
Cross-Price	–0.03	–0.28
	(–0.49)	–1.74)
Income	0.23	4.42
	(0.16)	(1.09)
Radiologists	–0.33	
	(–1.17)	
Physicians and Surgeons		1.80
		(1.77)
Constant	3.42	–21.37
	(0.60)	(–1.20)
Dummy Variables:		
Own-Price	0.47*	0.36
	(4.01)	(1.19)
Cross-Price	0.05	1.19*
	(0.49)	(3.97)
Income	3.74	–1.66
	(1.69)	(–0.25)
Radiologists	1.34*	
	(2.13)	
Physicians and Surgeons		0.68
		(0.38)
Constant	–19.87*	2.77
	(–1.98)	(0.09)
F	36.3*	12.13*
$\bar{R}^2$	0.67	0.39
SEE	0.32	0.93

Notes:
(i) OLS — ordinary least squares; F-statistic; $\bar{R}^2$ — coefficient determination, corrected for degrees of freedom; SEE — standard error of the estimate;
(ii) * significant at the 5 per cent level;
(iii) Data in parentheses are t-statistics.

The dummy variables in the two equations indicate if there are significant differences in the coefficients between the two groups, *viz*, pensioners and health care cardholders. There are three significant differences (own-price, the supply of radiologists and the intercept) in the radiology equation and one significant difference (cross-price) in the endoscopy equation. Thus there is some reason to believe that there were differences in the economic processes at work within these two schemes. An analysis of these differences is beyond the scope of this paper.

CONCLUSION

The purpose of this paper has been to provide some empirical evidence on whether a process innovation in medicine, *viz*, fibre optic endoscopy, has been utilised in practice as an economic substitute for barium meal radiology. This work has been undertaken as another economic approach that can shed some light on the debate that the diffusion of new medical technologies has caused health expenditures to rise.

After briefly reviewing the economic literature on the connection between medical technology and health expenditures, it has been argued that there is reason to be concerned with rising health expenditures associated with the diffusion of process innovations. Process innovations, of their very nature, are substitutes and hence would have positive cross-price elasticities of demand.

The empirical results presented here provide no evidence to indicate that these alternative technolgoies for diagnosing diseases/conditions of the upper gastrointestinal tract have been utilised as substitutes. No positive cross-price elasticities have been obtained. These empirical results indicate that the process innovation of fibre optic endoscopy has added to health expenditures associated with diagnosis of the upper gastrointestinal tract.

An important question that arises from the results presented here is why are these alternative diagnostic procedures not being used as substitutes by the medical profession? This paper does not address this issue. To consider possible explanations for this behaviour would require a separate paper.

The major limitation of the approach adopted here is that it involves a case-by-case approach. Further studies of this kind are necessary before a definitive conclusion can be reached on the connection between process innovations in medicine and health expenditures.

APPENDIX

This appendix presents summary statistics for the combined data sets relating to Health Care Cardholders and pensioners referred to in the text. The demand equations reported in the text have been estimated on these data.

TABLE A.1

Summary

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Barium meal radiology(i)	Number of procedures per 10,000 people covered	53.84	25.65	9.57	120.74
Endoscopy(i)	Number of procedures per 10,000 people covered	5.39	4.56	0.08	19.51
Net price of radiology(ii)	$s (constant 1980-81 prices)	0.79	0.61	0.11	3.68
Net price of endoscopy(ii)	$s (constant 1980-81 prices)	3.45	3.69	0.39	36.48
Income(iii)	$s (constant 1980-81 prices)	75.74	19.53	60.65	113.13
Radiologists(iv)	Number of radiologists per 10,000 people covered	3.14	0.42	2.16	4.38
Physicians and surgeons(iv)	Number of physicians and surgeons per 10,000 people covered	13.25	1.38	10.93	17.15

Sources:
(i) Health Insurance Collection and information supplied by Department of Social Security.
(ii) Calculated from Health Insurance Collection and adjusted by Consumer Price Index.
(iii) Standard age pension (for pensioners) and married unemployment benefit (for health care cardholders) supplied by Department of Social Security.
(iv) Permail Pty Ltd and Department of Social Security.

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