Modelling demand for medical services in Australia

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Abstract

This paper describes two new models of demand for medical services developed in Australia. The first, MedDemandMOD uses the National Health Survey to capture demographic, economic, regional and health need drivers of demand. The second, the Medicare model, uses data from the Australian national health insurance scheme Medicare and Census and related data to construct supply and demand equations for the Australian GP market.

Overview of recent research in the area

In Australia, work on demand has generally not been as rigorous as that published on supply and like most countries with similar health systems, Australia has also struggled to adequately model demand.

Estimation of demand for health services has not typically been presented in the way that economists would expect to see it defined – as the amount of goods that buyers are willing and able to purchase. Rather, "demand" has tended to be treated simply as the services currently supplied. The distribution of services by age and sex has then been used as the basis for projecting future "demand". The limitation of this approach is that existing unmet demand is not defined, and current inequalities resulting from the maldistribution of the health workforce are implicitly assumed to continue. Similarly, trend increases or declines in the demand or use of services either as a result of disease trends or changes in technology (for example, where new tests or treatments become available) have not been captured and projected, partly because the data that might be used are inevitably distorted by changes in supply[1,2,3,4] .Sometimes in the absence of estimates of demand, workforce requirements are based on other proxy measures such as a study of the radiology workforce which relied on vacancy rates, radiologist to population ratio, and reports of work over-load as indicators.[5]

Studies of demand in a more conventional market context have been undertaken in Australia[5,6,7,8,9], although these have tended to focus on particular issues, particularly the role of supplier inducement, rather than demand per se. The models are also subject to a number of technical criticisms. International studies of demand have tended to move from the aggregate approaches used in these studies to the use of individual data, and to the use of more sophisticated hurdle modelling and latent class modelling.[10,11,12]

In this paper we will describe two innovative models of demand for medical services recently developed in Australia. ***MedDemandMOD*** is based on the National Health Survey and the ***Medicare model*** based on Medicare administrative data. These studies provide quite different approaches and logics to the examination of demand, the former using individual data to model the impact of various non financial factors on demand for services, and the latter using aggregate data to estimate supply and demand equations and to examine the determinants of the location of the demand equation.

Methods and data sources

MedDemandMOD

The 2001 National Health Survey (NHS) undertaken by the Australian Bureau of Statistics is used as the data source for ***MedDemandMOD.*** The NHS has the advantage of being a nationally representative sample survey with a range of socio-economic and health determinants of medical demand.

The model was developed in SAS on an IBM compatible PC platform.

Medicare model

Data has been drawn from the Medicare administrative system for an eight year period from 1996 to 2003. Information on the number of GPs, the number of services provided, the prices charged, the level of government insurance paid and the number of patients seen in defined geographic areas, has been combined with aggregate data from the Australian Population Census, mortality data and data from a range of ad hoc sources (eg numbers of hospital beds and numbers of private schools) to provide the basis of this modelling.

The modelling was undertaken in STATA on an IBM compatible PC platform.

Modelling demand

MedDemandMOD

The rationale for ***MedDemandMOD*** was to develop a model of demand for general medical practitioner services that captured more than the typical age/sex supply of services. Rather, it was designed so that it could capture the impact of demographic determinants such as age, sex and regional factors such as remoteness, economic factors such as family income and socioeconomic indices such as SEIFA and indicators of need such as health status.

One of the first challenges was to account for unmet demand. Although an imperfect measure, it was assumed that in capital cities, where there is the highest concentration of general medical practitioners, demand was fully met. The limitation is that any unmet demand in capital cities is not captured. The total demand in underserved areas was then estimated to be the services that would be consumed if persons from other areas had the same supply of medical services as persons in capital cities given their health status (which is poorer), their demographic characteristics and factors that might constrain their use, such as family income (to meet out of pocket costs) and the composite socioeconomic index, the SEIFA Index of Relative Socio-economic Disadvantage.

SEIFA is a suite of four summary measures that have been created from Census information. For each index, every geographic area in Australia is given a SEIFA number which shows how disadvantaged that area is compared with other areas in Australia. On the NHS these numbers are made available as SEIFA quintiles with the first quintile being the most disadvantaged and the fifth the least. The SEIFA Index of Relative Socio-economic Disadvantage includes the following measures: low

income, low educational attainment, unemployment, and dwellings without motor vehicles[13].

The original intention had been to capture the use of general medical practitioner services by a range of characteristics as a continuous variable using a multiple regression model. However the survey only asked about the use of general medical practitioner services in the two weeks prior to the survey and a response of only 0,1, 2 or 3+ services used was recorded. Therefore, a multinomial logistic regression model was used to identify the variables that were significantly associated with the use of general medical practitioner services. The variables that proved to be significant determinants of service use were age, sex, family income decile, remoteness, SEIFA and self reported health status. Table 1 shows the results of the statistical significance test of the association of the use of general medical practitioner services with its determinants adjusting for other variables.

Table 1: Association of the use of general medical practitioner services with its determinants

Determinants	P-values[#]
Age group	< 0.0001
Sex	< 0.0001
Family income decile	< 0.0001
Remoteness	< 0.0001
SEIFA	0.0002
Self reported health status	< 0.0001
Family composition	0.5611

[#]P-values associated with the statistical significance test of the association.

Due to the very high proportion of 0 responses for the two week period (>75%)**,** the model overestimated the probability of not using any general medical practitioner services over the two weeks. Thus it was regarded as inadequate for policy purposes where the base simulation must at least accurately capture current service use.

Accordingly, a matrix (called an array in SAS when stored in memory to provide efficient access to a multidimensional matrix) of the average use of general medical practitioner services was set up. The variables which were found to be significant in the multinomial logistic function were used as the indices to the array. Some of the variables were collapsed to produce fewer categories so that there were relatively few cells with null values in the array. The total number of cells in the array was 648 (that is the number of permutations of the array variable categories (2x4x3x3x3x3). The variables used as array indices are defined in Table 2.

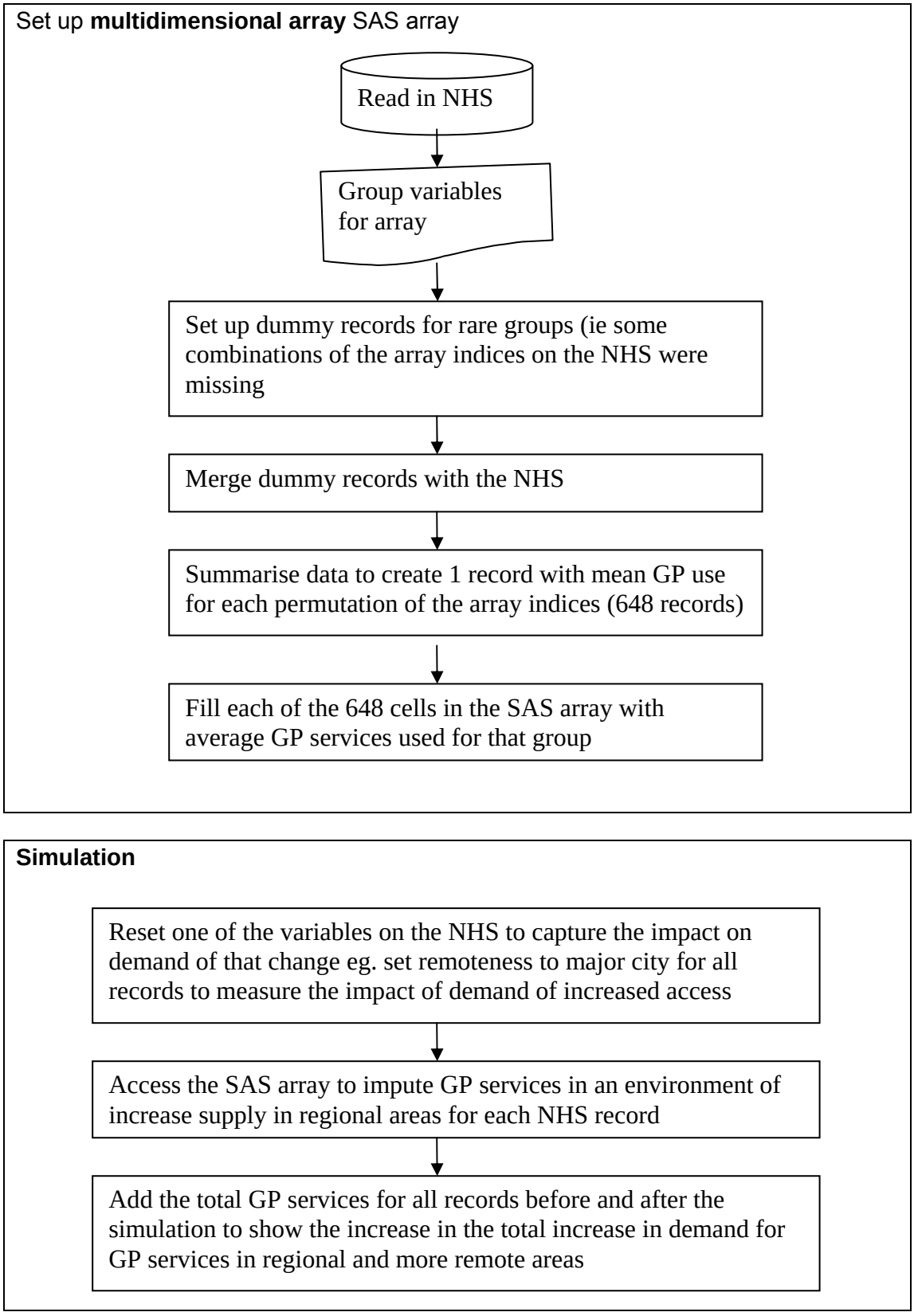
The data manipulation to set up and run the model provided to be quite complex. The example in Figure 1 shows a simulation of increased access to general practitioners in regional and remote areas. Similar simulations can be run to demonstrate the impact on demand of ageing of the population, changes to income, improved socioeconomic conditions for certain areas of Australia and changes to the health status of Australians.

Analysis and results from ***MedDemandMOD*** are described in a related paper by Schofield and McRae[14].

Table 2: Variables used to index the multidimensional array of average GP services used in the previous 2 weeks

Variable	Categories	Number of categories
Sex	Male, Female	2
Age group	15-20, 21-44, 45-64, 65+ years	4
Family income tercile	tercile 1, tercile 2, tercile 3	3
Remoteness	Major cities of Australia, Inner regional Australia, Other more remote areas	3
Self reported health status	Excellent/very good, good, fair/poor	3
Area SEIFA Index of Relative Socioeconomic Disadvantage	Quintile 1, Quintiles 2-3, Quintile 4-5	3

Figure 1: Diagram of *MedDemandMOD*



Medicare model

The ***Medicare*** model is a large scale multi-equation linear model of the Australian GP market. It was estimated using GMM fixed effects modelling to take advantage of the panel nature of the data. Equations were modelled separately (comparably with two stage least squares) rather than simultaneously, as while less efficient this is a more robust approach[15].

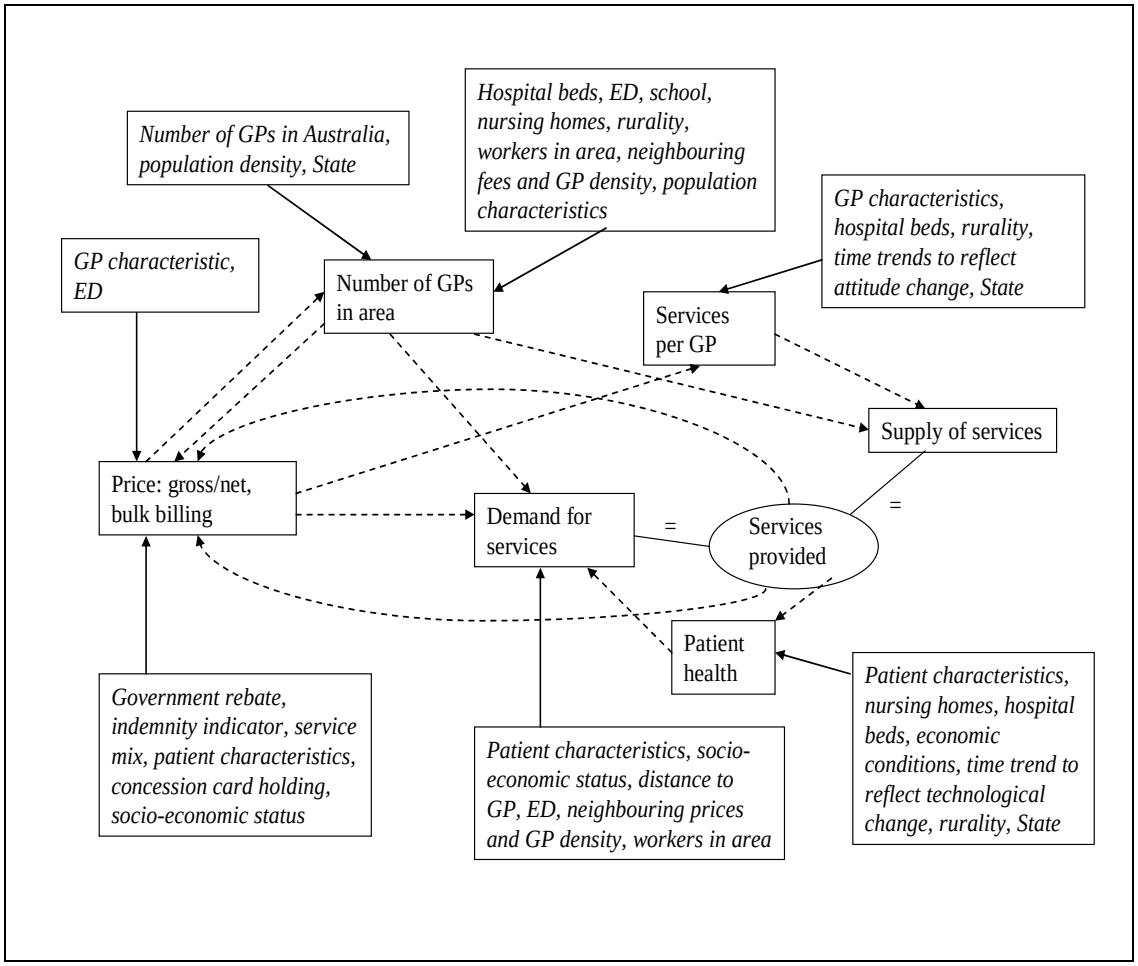
The data on which the modelling is based is drawn from Medicare, Census and other sources. The average values in 2001 for the main variables are shown in Table 3 below.

Table 3: Summary data for 2001

Variable	Mean	Min.	Max.
Population per SLA	23,786	887	189,776
Area of SLA (square kilometres)	9,356	1	671,466
Number of GPs per 1000 population	1.12	0.11	4.83
Percent of GPs: female	34.81	0	100
Percent of GPs: aged under 40 years	27.93	0	100
Percent of GPs: aged 60 or more	15.36	0	100
Percent of GPs: vocationally registered or in training	85.00	0	100
Services per capita	5.08	0.49	12.43
Services per GP	4,551	750	15,688
Average gross fee charged	$23.88	$18.01	$43.37
Average net fee charged	$2.21	$0.00	$20.84
Average MBS rebate	$21.67	$18.01	$34.31
Service mix (ratio of average MBS rebate to rebate for a standard consultation)	1.14	0.85	1.86
Average bulk billing rate (%)	76.23	0	100
Percent of population: female	50.69	25.43	58.64
Percent of population: aged less than 15 years	20.82	8.45	32.66
Percent of population: aged 65 years or more	12.60	0.94	30.11
Percent of population: with post school qualifications	18.65	3.05	48.36
Percent of population aged 15 years or more: unemployed	4.41	1.11	10.54
Percent of workforce: in blue- collar industries	25.44	6.33	78.13
Hospital beds per 1000 population	4.26	0	112.36
Nursing home beds per 1000 population	3.67	0	27.53
Crude death rate (per 10,000 population)	65.92	9.25	167.89
Percent of population with concession cards	35.83	4.85	78.23
Private schools per 10,000 population	0.19	0	5.49

Figure 2 shows the structure of the model, reflecting the high degree of simultaneity and hence endogeneity in the structure.

Figure 2: Outline of the Medicare model
(Standard text endogenous variables, italicized text exogenous variables, Dotted lines indicate relationship between endogenous variables)



The most important technical issues in the modelling were the establishment of appropriate instruments to permit the estimation of the supply and demand equations with confidence that the relevant variables were appropriately identified. Formal tests of instrument strength and the rank and order test of identification are met for the models estimated. The variables seen as identifying patient health and GP density are patient education and country of birth, and state level GP density (with a different definition of GP numbers) and numbers of hospital beds respectively.

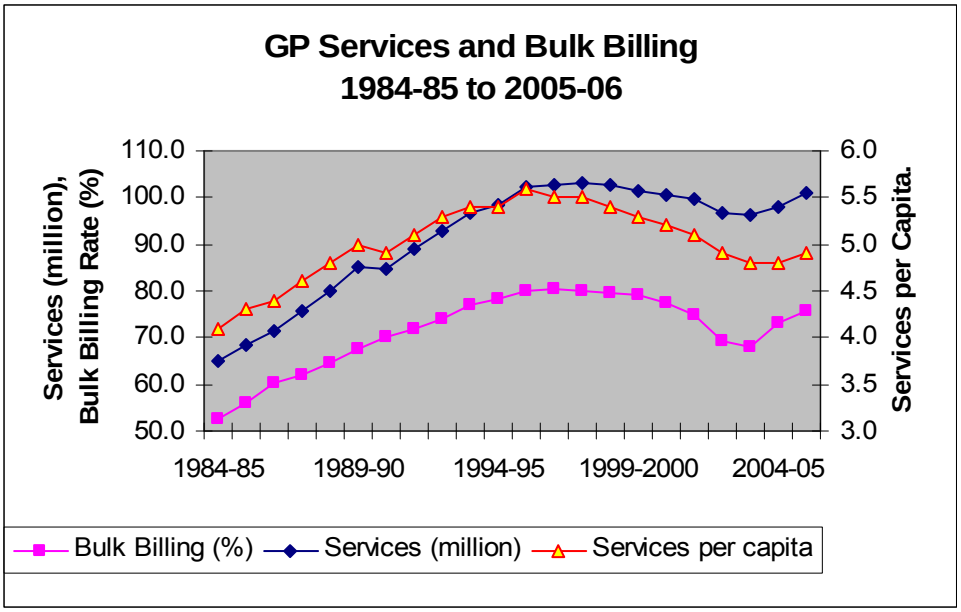
Models of demand and to a lesser extend supply of GP services have been estimated with aggregated data, particularly since 1978.[16] To a significant degree this approach ceased when problems of identification and border crossing were shown to materially influence results of the modelling.[17] The current model with its panel structure and wide range of explanatory variables overcomes these problems.

The rationale for modelling the Australian GP market with models which include price, and in which both supply and demand are estimated, is shown in Figure 3 which shows the history of the Medicare system in Australia. Although demand would be expected to be growing with population growth, an ageing population and

increasing chronic disease, the numbers of services fell during the late 1990s, only recovering after 2004 when large increases in government subsidies were provided.

In the Australian system there is no constraint on GP charging, but if GPs are prepared to accept the standard Government rebate as full payment (which is referred to as bulk billing) this is paid directly to them with no financial transaction required with the patient. The level of bulk billing, which is in a sense the obverse of the price faced by patients, follows a similar pattern to the service numbers.

Figure 3: GP services and bulk billing, 1984–85 to 2005–06



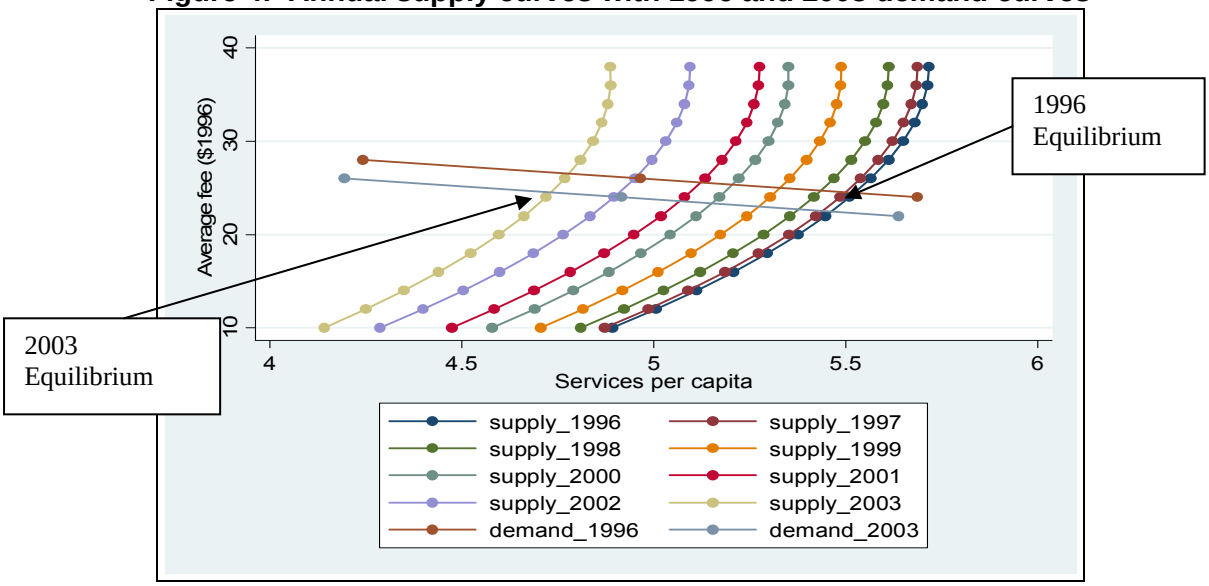
The modelling leads to estimated supply and demand curves for GP services in Australia. Figure 4 shows the curves across the period 1996 to 2003, and hence shows how the services provided have changed across this period. Attachment 1 shows the estimated supply and demand equations used to construct these curves.

Figure 4 shows that across this period at least, the main driver of both the changing volumes was the changing supply of services.

The main determinant of the level of demand curve was the level of government rebate which declined in real terms over this period. The other significant (but not large) factors in the panel equation were the health of the community (measured by crude mortality rates), the number of GPs in the community (included as a measure of supplier induced demand – while significant this factor was not material), and the unemployment rate in the area.

The main determinants of supply on the other hand, as would be expected, included GP numbers at a state level. Of more importance was the number of services GPs chose to provide, which depended on their age and gender, but also followed a clear downward trend which can be ascribed to attitudes to work-life balance and related factors. Its source, however, cannot be proven within this data set.

Figure 4: Annual supply curves with 1996 and 2003 demand curves



The Australian government made major changes to the levels and structure of the Medicare insurance rebate in 2004-2005 as well as taking steps to stop the fall in GP numbers (through migration in the short term and training in the longer term). The effects of these changes to 2006 have been estimated using the ***Medicare*** model which provided estimates extremely close to actual outcomes.

Discussion of the findings and issues for the future

MedDemandMOD

MedDemandMOD has significant advantages over the current methods to estimate "demand" used in Australia. It captures many of the main drivers of demand (age, sex, remoteness, family income, SEIFA and health status) and has the capacity to measure unmet demand. This has the particular advantage of supporting planning for more equitable access to medical services.

There are three main limitations of ***MedDemandMOD***. The first is that the number of general medical practitioner services used recorded on the NHS is only for a two week period. As a result, for statistical models, the data is not very useful for capturing the relationship between the use of health services and specific conditions such as asthma, diabetes or cancer that may result in a relatively higher number of services used but not over a two week period. Data that captures the total number of visits per year would be much more effective.

Secondly, the NHS does not have price information that administrative data such as Medicare data contains and therefore the financial constraints on demand of co-payments are not directly captured. There is a correlation between co-payments and the region in which the respondent lives with co-payments being higher in more remote areas. However this only captures this effect indirectly. As a result, when simulations altering the remoteness variable are undertaken they in effect capture the double effect of access (higher in the city) and co-payments (lower in the city), without being able separate the two effects.

The third limitation is that there is no equivalent to the variable "self-reported health status" for children under the age of 15 years on the NHS, meaning that children's demand for general medical practitioner services cannot be simulated with the current model. A simpler version of the model could be set up for children but it would have no measure of health need.

Medicare model

The approach to modelling in the ***Medicare*** model highlights the relative importance of demand and supply and their interrelationship in controlling the outcomes on the GP market. There is no absolute level of demand in this structure, only the demand at a given price. While changes in society will shift the position of the demand curve, the amount that the observed level of demand changes depends on the interaction between demand and supply. The supply curve is upward sloping at the relevant levels but it is not far from vertical. This means that a shift to the right of the demand curve will influence price, but will have very little effect on observed demand unless the supply curve also shifts.

The outcomes of the supply and demand interactions in Australia are observed in Figure 3 where the number of services per capita in Australia declined while the population aged and the crude mortality rate was relatively stable. Observed demand fell because of price effects and reduced availability of services. To consider the question of how much demand "should" have changed across this period, judgement would need to be made as to the "right" level of services in some sense, which is the approach taken in the ***MedDemandMOD*** model. The ***Medicare*** model cannot assist in consideration of the right level of demand.

The value of the ***Medicare*** model however, is that if such judgements are made it is possible to estimate the numbers of GPs and the levels of Medicare insurance rebates appropriate to generate the desired outcomes.

While the Australian national insurance scheme covers a high proportion of costs, Australia has an explicit fee for service system so any assessment of demand must be conditional on price. Many health systems, however, have zero or very low patient co-payment. This suggests a horizontal demand curve with observed demand strictly defined by supply.

An alternate view is that patients still face time and travel costs, and there will be a downward sloping demand curve with respect to these costs. Time and travel costs are highly dependent on the supply of GPs and how hard they wish to work in any area. In areas with few GPs, travel costs will be high and waiting times will be long: both in surgery and in terms of waiting to obtain an appointment. Even in systems with no out-of-pocket cost therefore there will be reduced demand in rural areas. The outcome of any shift in this curve due, for example, to population ageing will therefore again depend on the slope and any shifts in the supply curve in the particular health system.

ATTACHMENT

Supply and demand equations from the Medicare model

Table A1: Linear panel model of demand

Dependent variable : Services per capita				
	Coeff	**Sig**	**Robust std. err.**	**Elast'y†**
(Endogenous variables in italics)				
GPs per 1,000 population	0.591	***	0.126	0.129
Average net fee charged	-0.461	***	0.055	-0.190
Crude death rate	0.030	***	0.006	0.392
High border crossing ratio	0.801	***	0.092	
Low border crossing ratio	-0.380	***	0.085	
Average number of GPs per 1,000 in neighbouring SLAs	0.106		0.077	0.022
Average net fee charged in neighbouring SLAs	0.116	***	0.038	0.049
Percentage of population female	-0.035		0.031	-0.343
Percentage of population unemployed	0.081	***	0.021	0.074
Percentage of population aged 65 or over	0.002		0.029	0.004
Percentage of population aged under 15	-0.037	*	0.022	-0.149
Percentage of population Indigenous Australians	-0.027		0.024	-0.011
Indicator of second SEIFA quintile	0.013		0.044	
Indicator of third SEIFA quintile	0.079		0.065	
Indicator of fourth SEIFA quintile	0.027		0.089	
Indicator of fifth SEIFA quintile	0.138		0.118	
Note : * = significant at 10%; ** = significant at 5% ; *** = significant at 1%				
† elasticity at eight year mean values, not relevant for indicator variables				
Hansen J statistic: p-value	0.49			
Cragg-Donald statistic	21.58			

Exogenous variables used to instrument the endogenous variables:

- *Percentage of GPs vocationally registered.*
- *MBS rebate for a standard consultation.*
- *Indicator of the indemnity crisis.*
- *Number of GPs by State.*
- *Number of hospital beds per capita.*
- *Percentage of population with post school qualifications.*
- *Percentage of population born overseas.*

The supply of services offered by GPs in any area is the product of the number of GPs choosing to work in this area and the number of services each of them chooses to provide. Each of these factors is estimated separately in this system of equations

Table A2: Linear panel model of GP density

Dependent variable : GPs per 1000 population				
	Coeff.	**Sig.**	**Robust std. err.**	**Elast'y†**
(Endogenous variables in italics)				
Average gross fee charged	0.033	***	0.005	0.690
High border crossing ratio	0.230	***	0.028	
Low border crossing ratio	-0.147	***	0.024	
Average number of GPs per 1,000 in neighbouring SLAs	0.210	***	0.029	0.197
Average gross fee charged in neighbouring SLAs	-0.024	***	0.005	-0.499
Percentage of population aged under 15	0.003		0.005	0.054
Percentage of population aged 65 or over	0.052	***	0.006	0.571
Percentage of employed people who are blue collar workers	-0.008	***	0.003	-0.191
Hospital beds per 1,000 population	0.005	***	0.002	0.019
Private schools per 1,000 population	0.444		0.461	0.008
Nursing home beds per 1,000 population	0.001		0.004	0.003
Number of GPs per 1,000 in the state	0.952	***	0.083	1.070
Note : * = significant at 10%; ** = significant at 5% ; *** = significant at 1%				
† elasticity at eight year mean values, not relevant for indicator variables				
Hansen J statistic: p-value	0.59			
Cragg-Donald statistic	889.56			

Exogenous variables used to instrument the endogenous variables:

- *Service mix.*
- *MBS rebate for a standard consultation.*

Table A3: Linear panel model of services per GP

Dependent Variable: Average services per GP				
	Coeff.	**Sig.**	**Robust std. err.**	**Elasticity†**
(Endogenous variables in italics)				
Average gross fee charged	-0.052	***	0.007	-0.270
Percentage of GPs female	-0.013	***	0.001	-0.095
Percentage of GPs aged 60 or over	-0.007	***	0.001	-0.024
Percentage of GPs aged under 40	-0.009	***	0.001	-0.062
Percentage of GPs vocationally registered	0.023	***	0.001	0.425
Hospital beds per 1,000 population	-0.003		0.002	-0.003
Time trend	-0.063	***	0.004	-0.063
Time trend/inner regional interaction	-0.031	***	0.005	-0.006
Time trend/rural interaction	-0.022	***	0.007	-0.003
Note : * = significant at 10%; ** = significant at 5% ; *** = significant at 1%				
† elasticity at eight year mean values, not relevant for indicator variables				
Hansen J statistic: p-value	0.793			
Cragg-Donald statistic	1049.11			

Exogenous variables used to instrument the endogenous variables:

- *Service mix.*
- *MBS rebate for a standard consultation.*
- *Percentage of population with post school qualifications.*
- *Nursing home beds per 1,000 population.*

Overall Supply Offered

The overall supply of services GPs offered is calculated as the product of the number of GPs in the area and the average number of services they wish to provide. At the mean of all exogenous variables across the eight years[1] the relationship between the supply variables and the gross fee charged is:

GPs per capita = 0.6168 + 0.0195 * average fee charged

Services per GP = 5.8655 – 0.0537* average fee charged

The overall formulation is :

Supply = 3.906 + 0.079 * average fee charged – 0.001* average fee charged squared[2]

The equations for each year were estimated by similar means, using the relevant annual averages.

[1] The means were derived from the overall national means rather than the averages of the SLAs.

[2] Bootstrapped standard errors and p-values are: Constant 3.906, SE =0.527, p=0.000 ; coefficient on fee charged 0.079, SE=0.027, p=0.003; coefficient on fee square -0.001, SE=0.0003, p=0.002.

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