Forecasting hospital expenditure in Victoria: Lessons from Europe and Canada

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Abstract

This paper specifies an econometric model to forecast State government expenditure on recognised public hospitals in Victoria. The OECD's recent cross-country econometric work exploring factors affecting health spending was instructive. The model found that Victorian Gross State Product, population aged under 4 years, the mix of public and private patients in public hospitals, introduction of casemix funding and funding cuts, the proportion of public beds to total beds in Victoria and technology significantly impacted on expenditure. The model may have application internationally for forecasting health costs, particularly in short and medium-term budgetary cycles.

Introduction

Complex cost drivers, related to both supply and demand, have contributed to increases in health care expenditure across the globe. Demand side-effects are associated with increased income, ageing and increased insurance coverage (price effects). These demand side variables can explain only less than one-half of overall health expenditure growth. A large residual remains, which may be attributable to growth in medical personnel and facilities, technological development and rising real health care prices. These influences are described as 'supply effects',

since they often stem from the incentives facing providers of health care rather than patients. The impact of low marginal prices to consumers for new technology and treatment is also relevant (Oxley & MacFarlan 1994). However, health care professionals, through the agency role, still largely control access to these services. This results from information asymmetries combined with the institutional role of the medical profession (Evans 1984).

This paper develops an econometric (regression) model for forecasting State government expenditure on recognised public hospitals in Victoria. The study was undertaken by the Victorian Department of Human Services as part of the deliberations of a joint *Department of Human Services* and *Department of Treasury and Finance Working Party on Hospital Cost Drivers.* The OECD's recent cross-country econometric work, involving comparisons between countries on factors affecting health spending, was instructive. The paper covers the Victorian budget context and reviews econometric approaches to forecasting health expenditure, focusing on recent OECD analyses capturing both supply and demand factors. In developing the model, a detailed review of forecasting approaches was undertaken, including other econometric models, exponential smoothing, moving average and Autoregressive Integrated Moving Average (ARIMA). Actuarial and macroeconomic approaches to forecasting health care as a proportion of Gross Domestic Product (GDP) was also considered, along with demographic and utilisation changes. See Antioch et al. (1997) for a detailed discussion of these approaches.

Victoria's budget context

Victoria has made considerable progress over the past three years in improving its budgeting process. Broad budget decisions are now more timely, given the publication of an Autumn Economic Statement in April or May which provides broad departmental expenditure for the coming financial year. Departments and agencies funded by government therefore have earlier notification of their budget than was possible under the traditional August time lines.

The Autumn Economic Statement also shows three-year forward estimates of departmental spending based on an unchanged policy basis, but incorporating a standard annual productivity savings of 1.5%. Another major improvement is the move towards paying departments for the production of outputs.

As health is the largest single portfolio in the Victorian Government's budget, improved measurement of the portfolio's outputs and a realistic projection of forward expenditure based on those outputs is imperative.

In the acute health area, the department has adopted casemix weighted separations, called Weighted Inlier Equivalent Separations, as the major output

which is funded at benchmark rates. Benchmark rates have been assessed using Australian Bureau of Statistics data on per capita health spending in different States, and Commonwealth Grants Commission data on per capita hospital spending after allowing for factors such as dispersion and scale. These data were further refined to improve comparability, with a particular emphasis on comparing hospital costs in Victoria and New South Wales.

These comparisons showed that Victoria's per capita public hospital costs, which were some $65 above New South Wales in 1991–92, were about $20 lower in 1995–96. Estimates of increased demand for services in public hospitals were made for the 1995–96 and 1996–97 budgets based on historical trends in utilisation and an analysis of factors such as population growth, ageing, changes in the level of private health insurance and technological developments. This analysis of key variables impacting on costs, known as cost drivers, has been a significant advance over historical-based budgets. It has enabled a modest redistribution of resources within the State's budget between activities or outputs which are growing (for example, health) and those which are not growing (for example, primary and secondary education) before other policy considerations.

The Government's integrated management cycle also requires a formal presentation of a corporate and business plan, covering one to three years, from each department to government. From this plan, overall directions and particular budget parameters are derived, which consider particular changes in policy or program. This process is normally undertaken in the 4 months prior to the annual Autumn Economic Statement. However, such forward budgeting requires a more rigorous analysis of growth trends and cost drivers, and this paper represents one such approach (Antioch et al. 1997).

The model developed for this study was used within the Department of Human Services in discussions on budget forecasts during 1996 for the 1997–98 budget. Annual real and nominal hospital expenditure was forecasted for the years 1997–98 to 2000–01. Hospital expenditure was forecasted using projections of each of the significant independent variables and associated coefficients. Population estimates and consumer price index (CPI) projections from Department of Treasury and Finance were used to predict total nominal hospital inpatient expenditure from the real per capita expenditure estimates. The results of the model were reviewed and provided input into Department of Human Services deliberations prior to negotiations with the Department of Treasury and Finance and in the deliberations of the latter department's Budgetary Expenditure Review Committee. The estimates from the model provided one input into the discussions. Other approaches were considered and further adjustments were required for wages and specific policy initiatives such as information technology,

quality control, risk management, emergency and waiting lists. The results of the model were also considered within the Department of Human Services for internal budget allocation.

Econometric analyses of factors affecting health expenditure

Early work focused on the income elasticity of health care expenditure by linking per capita health spending to per capita GDP (Oxley & MacFarlan 1994). Newhouse (1977) concluded that aggregate income explains 92% of the variance in the level of health care expenditure between countries and that income elasticity of health care expenditure exceeds 1. Income elasticity of demand measures the responsiveness of the quantity demanded to changes in income. An income elasticity greater than 1 implies that the level of health care expenditure is very responsive to changes in income.

Newhouse (1977) made two strong inferences. First, factors other than income, for example, the price paid by the consumer and the method of reimbursing the physician, are of marginal significance. Second, health care is technically a 'luxury good' since demand at the margins relates more to 'caring' than to 'curing'.

Leu (1986) also confirmed the predominant effect of the income variable. In addition, he found that a 10% increase in the public to total bed ratio increased overall spending by 8–9%. National health systems in the United Kingdom and New Zealand were associated with 20–25% lower spending. These conclusions have remained controversial and Gerdtham et al. (1988, 1992a) were not able to reproduce the results gained by Leu (1986).

Gerdtham et al. (1992a) found that five independent variables accounted for 95% of variance: per capita GDP, urbanisation, proportion of public finance, share of inpatient expenditure in total and whether or not fee-for-service existed. In contrast to Leu (1986), an increase in the share of public financing by 10% was associated with 5% lower spending. A 10% increase in share of inpatient expenditure had a positive impact on spending of 2%. Spending was 11% higher in fee-for-service countries.

Gerdtham et al. (1992b) found that two non-income variables in addition to the previous five were significant. A 10% increase in the share of the population over 64 years of age increased health care spending by 2%. A 10% increase in the number of physicians per capita reduced spending by 10%. Gerdtham et al. (1994) found the latter result difficult to explain.

Hitiris and Posnett (1992) identified three key relationships. First, a strong positive relationship was found between per capita health spending and GDP, consistent with an income elasticity of approximately unity. Second, the impact

of non-income variables was considered. The elasticity of health spending for the proportion of the population over 65 was 0.55. The effect of the public finance share of total health spending was not significant.

The OECD (1993) analysed expenditure trends for the years 1985–1990. Health expenditure and GDP were specified as totals rather than in per capita terms. The income elasticity of health expenditure was over 1.5. Relative prices had a negative elasticity of around 1, suggesting that lower real spending on health care offset higher prices. A higher public share of total spending was associated with lower rather than higher health spending. Coefficients for the young and old were significant. The aged consumed around four times as much as the rest of the population.

Gerdtham et al. (1994) analysed trends in 20 countries for a 20-year period. The hypotheses emphasised the contractual relations between payers, providers and patients. The study analysed inpatient, ambulatory and pharmaceutical expenditure and total spending. The variables were divided into two groups. The first included common, non-institutional (or 'background') factors to specify a basic model of population age structure; GDP per capita; a proxy for substitution from home to institutional care called the female participation rate in the labour force; the unemployment rate; and tobacco and alcohol consumption. The second group focused on the institutional arrangements impacting on funding, demand and delivery of health services.

Total health spending and its three main sub-components were regressed on all of the variables simultaneously. Non-significant variables were then excluded one by one and the model re-estimated. Regressions were estimated in which various subgroups of the 'institutional arrangement' variables are added to the basic model, including the addition of institutional variables one at a time. This is important because there may be overlap between the institutional variables. The equation was written in double-logarithmic linear form, implying that the coefficients of the variables are to be interpreted as constant elasticities (Gerdtham et al. 1994). The approach has been shown to be the most appropriate empirically (Gerdtham et al. 1988, 1992a, 1992b; Gerdtham 1992).

Amongst the background factors, only GDP and tobacco consumption had a significant effect on health spending. Among the institutional variables, public reimbursement systems was the least expensive. Countries with budget ceilings on inpatient care appeared to have higher spending, while a higher number of doctors was related to lower spending. The share of inpatient care expenditure tends to be positively related to overall expenditure. Contrary to hypotheses in previous work, a higher share of public coverage of medical care billing and of public beds to total beds generated lower overall expenditure, although the

impact was not robust across the sample. Public reimbursement systems tended to be less expensive than public contract systems, although the significance was not robust over different country groups and time periods. There was no evidence to support the hypothesis that public integrated systems are less expensive than public contract systems once allowance is made for the effects of the share of inpatient care and gatekeeping arrangements.

Systems with budget ceilings in ambulatory care did not appear to be less expensive than systems without budget ceilings. Similarly, budget ceilings in inpatient care do not seem to lower overall expenditure. Countries with primary physicians as gatekeepers for inpatient care have consistently lower overall expenditure. Countries with more doctors per capita have lower overall expenditure. Although this result was unexpected, given the potential impact of supplier induced demand, it was consistent with earlier studies. However, it seems that the number of doctors increases overall expenditure in systems which reimburse their physicians by fee-for-service. Countries which reimburse their physicians by capitation appear to have lower overall expenditure. However, countries reimbursing physicians by salaries are not associated with lower overall expenditure than those using fee-for-service. Overall expenditure was not higher where payments were by bed-day or fee-for-service in inpatient care. Countries where the patient pays the provider and then seeks reimbursement tend to have lower overall expenditure.

Inpatient care expenditure

Gerdtham et al. (1994) undertook a separate regression for total inpatient care expenditure as part of the OECD study. This was most instructive in the current Victorian study. Several background variables, including the proportion of the population aged 4 years and under, the female participation rate, and alcohol were individually and jointly insignificant, and were eliminated in the second regression. The tobacco consumption and GDP terms remained, each with significantly positive impacts on inpatient expenditure. The elasticity of GDP was lower than unity (0.7) and a 10% increase in tobacco consumption increases inpatient spending by approximately 1.4%.

The average share of medical billing paid by public insurers in inpatient care was included in the analysis. There was no evidence that such co-payments have a positive impact on inpatient care expenditure; a significant negative impact was obtained. A positive impact was found for the share of inpatient care in overall expenditure on the level of expenditure. This may indicate that there is a substitution relationship between inpatient care and other forms of care.

The share of public beds in total beds was negatively related to total inpatient care expenditure. The insurance coverage ratio inpatient care had a positive impact. Public reimbursement systems were associated with lower expenditure. Public integrated systems did not appear to influence the level of expenditure. However, the results for the three foregoing variables were not robust across the sample of countries nor time periods.

Ceilings on inpatient care expenditure were associated with significantly higher expenditure. Ambulatory gatekeepers had a significant negative impact on expenditure and was robust across both country and time samples.

Doctor numbers had a robust positive impact on inpatient expenditure in countries which reimburse their physicians by fee-for-service. The number of doctors per capita did not influence inpatient expenditure. Capitation arrangements in primary care lowered expenditure but was not robust across the sample of time periods. Fee-for-service arrangements in inpatient care did not affect expenditure, nor do systems where patients seek reimbursement from insurers for inpatient expenses they have incurred. The renal dialysis rate per million was associated with a significantly higher level of expenditure and was robust across the sample of time periods but not across countries.

The impact of the number of doctors per capita on health expenditure varied depending on whether the dependent variable was total health expenditure or inpatient health expenditure. Countries with more doctors per capita have lower overall total health expenditure. However, where fee-for-service payment is used, the number of doctors *increases* overall expenditure. For inpatient care, the number of doctors per capita did not influence inpatient expenditure, except where physicians are reimbursed by fee-for-service, where the number had a positive robust association on inpatient expenditure. The strong positive effect of fee-for-service is clear for both inpatient and total expenditure.

Methods

We turn now to the methodology used in the Australian setting, which was guided by the OECD model. The aim was to develop coefficients that can be used to forecast public hospital expenditure, using population estimates and the CPI to predict total nominal hospital inpatient expenditure from the real per capita estimates. The regression approach used to develop the Victorian model involved running multiple regressions to determine significant independent variables impacting on real State government per capita expenditure on recognised public hospitals (RSPERPH). The CPI was used as the deflator of expenditure.

The *general* model for the analysis is outlined below and incorporates some of the key variables identified by the OECD (1993), Gerdtham et al. (1994) and Gerdtham (1992). Additional variables have been added, reflecting the institutional arrangements in Australian States. See Antioch (1997) for a detailed rationale for the choice of variables. Forecasts based on the model would require adjustment to reflect clear policy changes articulated by a government department already inherent in the budget process. A double-logarithmic linear model was developed. This approach has been previously demonstrated to be the most appropriate empirically (Gerdtham et al. 1994).

The independent variables were divided into two groups. The first included common, non-institutional (or background) factors to specify a basic model of population structure (POP 75% and POP 04%), Gross State Product (GSP), a proxy for the substitution from home to institutional care called the female participation rate in the labour force (FPR), and the unemployment rate (UNR). Tobacco (TOBC) and alcohol (ALCC) consumption have been used in previous studies by the OECD, but were excluded here given that the effects of these two variables are lagged and were considered too indirect an influence (Antioch et al. 1997). The second group of variables focuses on the institutional arrangements impacting on funding, demand and delivery of health services. The theoretical framework for econometric analyses by Kennedy (1992) facilitated model development and statistical analyses. The equation took the following form.

$$\ln(\text{RSPERPH}) = B0 + B1\ln(\text{GSP}) + B2\ln(\text{POP75\%}) + B3\ln(\text{POP04\%}) + B4\ln(\text{FPR}) + B5\ln(\text{UNR}) + B6\ln(\text{PUSH}) + B7\ln(\text{REND}) + B8\ln(\text{RPHC}) + B9\ln(\text{URB}) + B10(\text{CMF}) + B11\ln(\text{PUBPRIV}) + B12\ln(\text{SDSEPS}) + E$$

Table 1 contains definitions of all variables. The definition relating to coefficients B1 to B7 are derived from OECD (1993) analyses. The OECD used GDP for cross-country comparisons. For the Victorian study, GSP was used.

Gerdtham (1992) used two additional variables, namely, the relative price of health care (RPHC – the ratio of purchasing power parities (PPP) for medical care to PPPs for GDP) and urbanisation (URB – percentage of the population living in towns with over 500 000 inhabitants). For RPHC in this study, the Health Care Price Index and CPI were used.

The additional variables included to reflect Victoria's institutional arrangements for hospital inpatient care are variables B10 to B12. CMF – Casemix funding was used as a new dummy variable to capture the effects of the funding cuts introduced in the same year as casemix funding (1993–94). PUBPRIV is the ratio of public separations to private separations in Victorian public hospitals and

SDSEPS is the ratio of non-same-day separations to same-day separations in Victorian public hospitals.

The OECD model used as the basic framework for this study was designed for a comparison between countries for an analysis of total expenditure and its components. It was constrained by the availability of international data. Some variables will vary much more between nations than within Victoria over a limited time period. That is, the significant variables in the OECD study need not be significant in the Victorian analysis (Antioch et al. 1997). The data were analysed by quarter over the period 1988 to 1995. The following hypotheses were formulated for Victoria, following consideration of the international research frameworks, results and given Victorian institutional characteristics.

The hypotheses and regressors are discussed as follows.

GSP Does Victorian GSP per capita impact on real State government per capita expenditure on recognised public hospitals (RSPERPH)? Rising GSP could theoretically lead to increased uptake of private health insurance, self-insurance or a slowdown in the reduction of private insurance coverage.

This could theoretically lead to a fall in RSPERPH due to *reduced* demand for public services. Whether the coefficient estimated is positive or negative will depend on the income elasticity of demand for private health insurance. Recent experience shows falling coverage for health insurance in Victoria, in the face of increasing incomes. This effect is not surprising, given the effect of universal public insurance coverage provided by Medicare. This is suppressing the relationship between income and private health insurance uptake. However, with higher incomes, those with private health insurance may be more inclined to use private hospitals, even in the face of co-payments, thereby reducing pressure on public hospitals. In Victoria this trend has emerged in private hospitals vis-a-vis declining private patients in public hospitals. The direction of the effect of GSP was not specified a priori.

POP75% Does the proportion of the population 75 years and over in Victoria impact on RSPERPH? A rise in the proportion of elderly in Victoria is expected to lead to higher RSPERPH due to their greater utilisation of public hospital services.

POP04% Does the proportion of the population 4 years and under in Victoria impact on RSPERPH? It is thought that a higher proportion of infants in Victoria will lead to higher RSPERPH due to greater utilisation of public hospital services by this age group, particularly neonates.

FPR Does the female labour force participation ratio (percentage of active population) in Victoria impact on RSPERPH? The substitution from home to institutional care represented by a rise in the FPR may increase RSPERPH. That is, a rise in the FPR will imply that there are less carers available at home. This is thought to force some individuals into institutional care. Therefore a positive relationship between FPR and RSPERPH is expected.

UNR Does the unemployment rate in Victoria impact on RSPERPH? Rising UNR generally coincides with weak GSP growth. This can lead to increased demand for public-funded health. Further, increased unemployment is also associated with declining health status, increased health need and greater utilisation of hospital services. Both of these trends imply a positive relationship.

PUSH Does the proportion of public beds to total public and private beds in Victoria impact on RSPERPH? A rise in the proportion of public beds to total beds in the State will increase RSPERPH due to falls in private income for public hospitals and also the public sector costs for increased public patients. A positive coefficient is expected.

REND Does the level of high-cost procedures such as dialysis impact on RSPERPH? Does the renal dialysis rate per million population in Victoria impact on RSPERPH? The direction of the effect was not specified a priori. There is a substitution effect associated with the use of renal dialysis vis-a-vis renal transplantation. Two possible scenarios could be expected with the renal dialysis rate. Firstly, increases in REND may lead to reductions in RSPERPH in the short term because it substitutes for costly surgery. Alternatively, an increase in REND may lead to rises in RSPERPH because of the capital cost of hospitals acquiring suitable technology and also the *long-term* costs associated with a procedure used for a chronic condition.

RPHC Does the relative price of health care in Victoria (ratio of health services index to CPI) impact on RSPERPH? It is expected that increases in the relative price of health care will directly lead to rises in RSPERPH due to impact of price rises in the health sector.

URB Does the percentage of the population living in towns with over 500 000 inhabitants (that is, categorised as urbanised) in Victoria impact on RSPERPH? Rising rates of urbanisation could induce consumers of health care to increase utilisation due to improved access to health care or availability of services. Increased utilisation would imply higher RSPERPH, that is, a positive coefficient is expected. However, there may be a negative effect, with a fall in urbanisation leading to increases in RSPERPH. A greater proportion of the population living in more remote areas would require increases in hospital funding due to higher cost structures, for example, visiting medical officers and reductions in economies of scale. A direction of the effect of this variable was not specified a priori.

CMF Dummy variable. 'Zero' for the time period before casemix funding *and* funding cuts introduced in Victoria. 'One' otherwise. This variable will 'explain' the large reduction of health expenditure in the time series. Called casemix funding but also captures the impact of significant budget cuts. Both introduced simultaneously in 1993–94.

PUBPRIV Does the ratio of public inpatient separations to private inpatient separations in Victorian public hospitals impact on RSPERPH? It is expected that an increase in the ratio of public separations to private separations in Victorian public hospitals will increase RSPERPH due to increasing pressure of public patients on public hospitals and reductions in private income accruing to public hospitals. Hence a positive coefficient is expected.

SDSEPS Does the ratio of non-same-day separations to same-day separations in Victorian public hospitals impact on RSPERPH? It is expected that a rise in non-same-day separations would increase RSPERPH due to the increased cost of a rise in average bed-days per separation, especially in the face of declining average length of stay and higher acuity of inpatients in hospitals. Conversely, a rise in the number of same-day separations (implying a fall in SDSEPS) is expected to lead to reductions in RSPERPH. Hence a positive coefficient is expected.

Table 1: Definition of variables

Variable	Definition
RSPERPH	Real State per Capita Expenditure in Recognised Public Hospitals.
GSP	Victorian Gross State Product per capita.
POP75%	The proportion of the population 75 years and over in Victoria.
POP04%	The proportion of the population aged 4 years and under in Victoria.
FPR	The female labour force participation ratio (percentage of active population) in Victoria.
UNR	The unemployment rate in Victoria.
PUSH	The proportion of public beds to total public and private beds in Victoria.
REND	The renal dialysis rate per million population in Victoria.
RPHC	Relative price of health care – the ratio of the Health Services Index to the CPI.
URB	The percentage of the population living in towns with over 500 000 inhabitants in Victoria.
CMF	Dummy variable. 'Zero' for the time period before casemix funding and funding cuts introduced in Victoria. 'One' otherwise.
PUBPRIV	The ratio of public inpatient separations to private inpatient separations in Victorian public hospitals.
SDSEPS	The ratio of non-same-day separations to same-day separations in Victorian public hospitals.

Diagnostic tests were undertaken to check for autocorrelation, structural stability, normality and functional form. A general specification was used, for example, all variables were lagged to determine their statistical significance.

The model was chosen because it was considered the best fit of the data after the process of excluding all insignificant independent variables was completed. The method of excluding insignificant variables was based on the 'top down' approach where insignificant independent variables are gradually excluded on a step-by-step basis, that is, stepwise linear regression.

Each exclusion step involves running a number of regressions with different variable combinations in an effort to identify variables that are insignificant in all circumstances. When a variable was found to be insignificant across a wide range of model specifications, it was excluded. 't-statistics' were used to decipher which variables were significant at a 95% level of confidence. (that is, $t > 1.65$).

Results

The results, identifying significant variables, enable the following to be specified.

ln (RSPERPH) = 1.2312 ln (GSP) + 2.7854 ln (POP04%) + 1.8630 ln (PUSH) – 0.1028 (CMF) + 0.2708 ln (PUBPRIV) – 0.2127 ln (REND)

Variable	Coefficient	t-statistic	Prob
GSP	1.2312	2.2256	0.0361
POP04%	2.7854	15.8698	0.0000
PUSH	1.8630	1.9460	0.0640
CMG	-0.1028	-3.9063	0.0007
PUBPRIV	0.2708	2.5053	0.0198
REND	-0.2127	-2.2898	0.0315

Adjusted R squared	0.7520
Standard error of regression	0.0356
Durbin Watson	1.9930
F-statistic	17.9843
Prob (F-statistic)	0.0000

The GSP variable was lagged by two quarters. The proportion of the population over 75 years (POP75%), female participation rate (FPR), unemployment rate (UNR), relative price of health care (RPHC), urbanisation rate (URB), and the ratio of non-same-day separations to same-day separations in Victorian public hospitals (SDSEPS) were insignificant and excluded. This leaves a relatively simple model embodying the key institutional variables, GSP, population and technology.

The Durbin Watson statistic, testing for autocorrelation, was 1.99, an excellent outcome. Adjusted R squared was 0.752, standard error of regression was 0.0356, F-statistic was 17.98 with alpha significance of .0000. The actual, fitted and residuals were plotted and appeared reasonable. The standard error of the residual was plotted and the associated Jarque-Bera was 3.310587 with a probability of 0.191036, which is within the acceptable range. The White Heteroskedasticity Test was undertaken, involving regressing the residuals across the independent variables. The results indicate that there is no heteroskedasticity in the data since none of the t-tests was significant. The CUSUM of squares was undertaken to test for structural breaks. There were no structural breaks other than the funding cuts in 1993, which accounts for the time period 1993 to 1995 being captured in the graph.

Discussion

Gross State Product and ageing

The current research focuses on *government* per capita expenditure on recognised public hospitals in Victoria. Comparisons with studies from broader coverage of *total* health expenditure aggregates, which may include both public and private expenditures, should be treated cautiously. Likewise, cross-country studies use different variable combinations to the current study, which analyses changes over time in one Australian State. That said, the research has revealed some very interesting and exciting similarities with previous research in this area.

Most previous work using cross-section data (Newhouse 1977) has shown a positive relationship between GDP and per capita health expenditure. Most studies using national aggregated data have confirmed Newhouse's results (Gerdtham et al. 1994). The current research found a significant positive relationship between government per capita expenditure on public hospitals and per capita GSP, consistent with earlier findings.

Newhouse (1977) concluded that the income elasticity of health care expenditure exceeds one. However, evidence obtained from national household level data such as Grossman (1972) and Newhouse and Phelps (1974) found a low income elasticity for health care utilisation across households. This may occur due to the income constraint being more compelling at the *aggregate* level than at the individual level, whereby individuals pay only a minor fraction of health care costs as direct out-of-pocket payments. The possibility of mis-specification of estimates is another reason for the difference, that is, the high income elasticity at the aggregate level may reflect omitted variables such as supplier induced demand (Gerdtham et al. 1994). Supplier induced demand was omitted from the current study due to lack of data.

The need to lag GSP is consistent with the findings of Getzen and Poullier (1992). They indicate that the health sector tends to lag the rest of the economy so that its growth in any particular year is a function of income over several previous years.

The current study findings were consistent with Getzen and Poullier's (1992) finding that once per capita income effects are included in a fully specified model, population ageing no longer has any significant independent effect on health spending. We found that the proportion of the population aged over 75 was not a significant variable, and per capita GSP was significant. Barer et al. (1987) note that the direct cost driving effect of the elderly is from the rising relative *intensity* with which the health system treats the elderly, not simply the increase in the proportion or number of elderly. Future econometric models could focus on measures of the changes in the *per capita utilisation* of those aged over 75 years in Victoria, rather than the proportion aged over 75.

Leu (1986) had confirmed the predominant effect of the income variable and the increase in the public to total bed ratio would increase spending by 8–9%. Again, this is consistent with the current research – a significant positive relationship was found between the ratio of public to total beds and per capita expenditure on recognised public hospitals.

The direction of the effect of GSP was not specified a priori due to the interactive effects of a national policy of not charging public patients in public hospitals and the relatively high costs of private health insurance coverage. Clearly, public patients face no out-of-pocket payments and their income may not have a big influence on their demand as a 'public patient'. In Australia, the effects of GSP might impact through the uptake of private health insurance. Therefore, increases in GSP and income *might* lead to increased coverage of health insurance and reduced pressure on the public sector.

This has not occurred. Surprising? Not at all! This is likely due to adverse selection and market failure inherent in health insurance markets (and accentuated by Australian arrangements). And this occurs across the globe! That is another study. See Evans (1984) for an excellent discussion on the dynamics of such factors and the Productivity Commission's (1996) review of private health insurance and Hall, Viney and De Abreu Lourence (1997) for the analysis within the Australian context.

In considering government funding, increased GSP is likely to lead to increased government revenue via taxation; therefore, an increased ability of government to spend on public hospitals. This positive relationship was found in the study.

Proportion of the population aged 4 years and under (POP04%)

The coefficient for the proportion of the population aged 4 years and under was positive as expected. Children aged 0–4 years may demand more health care than average, hence a rise in the proportion of this age group should imply an increase in RSPERPH. This contrasts with the OECD's findings showing a non-significant effect of this variable on inpatient spending. However, an OECD (1993) study of total health expenditure found a positive coefficient for the young.

Proportion of public beds to total public and private beds (PUSH)

The coefficient indicates that as the proportion of available public beds to total beds in Victoria rises, public hospital expenditure increases. Falling private patient income in public hospitals and increased government expenditure may result from rises in the public/total bed ratio in Victoria. Roemers' law is relevant here, whereby an empty bed might certainly soon become a filled bed. This law

proposes that hospital bed utilisation is causally linked to bed availability, independently of population morbidity or user charges. The effect is not merely a capacity constraint. Bed availability is argued to affect physicians' predisposition to hospitalise in addition to the number of individuals they can place in beds (Evans 1984). Capturing the bed availability in the public hospitals relative to the entire hospital sector (public and private hospitals combined) provides a measure, albeit indirect, of the potential for changes in throughput in the public hospital sector (Antioch 1997). The OECD found that the share of public beds to total beds was negatively related to total inpatient expenditure. However, they were exploring the relationship between the 'bed ratio' and total (public and private) health expenditure in some countries and the difference in findings is not surprising. The current study only captures public expenditure. Leu (1986) found that the increase in the public to total bed ratio would increase health spending by 8–9%.

Funding cuts and casemix funding (CMF)

The coefficient for the dummy variable that represented the funding cuts and the introduction of casemix funding indicates, as expected, that these lead to falls in RSPERPH. In preparation for the 1993–94 financial year, the government announced a policy aimed at eliminating the current account deficit through a range of strategies. Public sector outlays were targeted for a $730 million reduction over the two-year period commencing 1993–94. The Department of Human Services acute health program comprised 14% of public sector outlays but was requested to contribute 30% of the government's overall savings targets. This amounted to $225 million over the 1993–94 and 1994–95 financial years. This represented cuts of 10% over and above the previously applied cuts of 4% in 1992–93 and 1.5% since 1990. The Victorian Commission of Audit concluded that Victoria could make savings of this order. Casemix would be implemented immediately and would be supported by a firm industrial relations policy and voluntary departure packages. Clearly, casemix funding did not cause funding cuts; it was introduced at the same time as the funding cuts. Casemix funding simply provided the incentives to change the method allocating the funds that were available.

Ratio of public to private inpatient separations in public hospitals (PUBPRIV)

The coefficient for the ratio of public inpatient separations to private inpatient separations was positive, indicating that rises in the proportion of public separations may imply rising RSPERPH. It was expected that an increase in the ratio of public separations to private separations in Victorian public hospitals

would increase RSPERPH due to increasing pressure of public patients on public hospitals and reductions in private income accruing to public hospitals.

Renal dialysis rate per million population in Victoria (REND)

The coefficient for renal dialyses indicated that an increasing treatment rate should imply a fall in RSPERPH. Increases in REND may lead to reductions in RSPERPH because it substitutes for costly surgery in the short term. However, the reduction in RSPERPH in the longer term may reflect the substitution of more cost-effective ambulatory treatment for renal dialysis vis-a-vis inpatient hospital care. The OECD had included the renal dialysis rate per million and was associated with a significantly higher level of inpatient care expenditure. However, the effect was not found across all countries.

The OECD used renal dialysis as a proxy for higher cost procedures such as transplants. However, there can be a substitution effect working here whereby renal dialysis is used in the absence of expensive transplants. Further studies could use technologies that fall into the category of high-cost/high-volume (such as traffic accidents) or high-cost/low (but growing)-volume. Extra corporeal membrane oxygenation, may prove useful here, particularly given that the under 4 years population was a significant cost driver in the current Victorian study. Transplants could also be used.

Female participation rate (FPR)

The OECD and the current study used female participation rate to measure the drivers of substitution from home to institutional care, represented by a rise in FPR. Previous studies have hypothesised that a rise in FPR could imply that there are less carers available at home and may force individuals into institutional care. Further studies could use improved measures of the drivers of change in substitution between institutions and home. Recent health policy direction in Australia and elsewhere has focused on the move from institution to the home and physician practice patterns encourage lower length of stay and early discharge. There is also greater substitution of ambulatory care for inpatient care, which has been facilitated by technological developments. Changes in clinical practice patterns have had a large impact on length of stay in hospitals. As average length of stay generally declines for various diseases and conditions, the burden of care shifts to the home, irrespective of the female participation rate. Females will have to take time off work to care for the sick, and are assisted by expanded community support facilities.

It is not surprising that the FPR was an insignificant independent variable in the Victorian study. The variable SDSEPS (ratio of non-same-day separations to

same-day separations) is a more direct variable that captures the change in the increase in the ambulatory caseload relative to inpatient care. Future studies could explore changes in average length of stay for those AN-DRGs with the largest throughput and where early discharge has been encouraged, to capture the impact of the shift from institutions to the home. These trends may be associated with increased costs, given that the caseload left in the hospitals comprises the more acutely ill, since the convalescent period occurs in the home, with community support.

Conclusion

Projections of each of the significant independent variables, and associated coefficients have been used to forecast the expenditure in the budget cycle in Victoria for 1997–98. The results have also been used for internal budget allocation within the Victorian Department of Human Services. The variable PUBPRIV (ratio of public inpatient separations to private inpatient separations in public hospitals) is an important cost driver. While policy changes on the waiting lists and additional throughput pool (through changing the variable price, and capping in some quarters) may impact on costs, these impacts are a very small proportion of the entire public hospital 'bill' and are best captured outside the regression model (Antioch 1997).

Broad government policy such as competition policy and the results of Commonwealth–State negotiations under the Medicare Agreements also impact on the funding available and expenditure. The impact of broad government policy such as competition policy was considered when forecasting the independent variables in the model, through adjustments for a larger private sector role in the hospital industry in the longer term.

Further research that aims to develop regression models for health expenditure could incorporate a variable to capture supplier induced demand, such as the number of doctors per capita. Further, changes in the per capita utilisation of health services by the elderly could be included.

The findings of the current work and associated methodology may be instructive for other Australian States. The OECD could use the findings to further refine and develop variables for regression models and could consider the application of such models for prediction. Little work appears to have been done to date by the OECD in prediction. This would be a logical next step for its application in policy circles internationally.

Definition of terms

ARIMA

This term refers to Autoregressive Integrated Moving Average. The main competitor to econometric models for forecasting is time series analysis, also called Box Jenkins analysis. Rather than using explanatory variables to forecast, time series models rely only on the past behaviour of the variable being predicted. When the model expresses the dependent variable only in terms of its own past values along with current or past errors, it is called an ARIMA (Kennedy 1992).

Autocorrelation

The Classical Linear Regression model includes several assumptions about the way the observations are generated. A key assumption is that the disturbances (or error) terms all have the same variance and are not correlated with one another. A major econometric problem is associated with violations of this assumption. Autocorrelation or an autocorrelated error occurs when the disturbances are correlated with one another (Kennedy 1992). Thus the residuals are not occurring at random but are systematically related to each other.

CUSUM of squares test

The CUSUM of squares test is based on the cumulative sum of the squared recursive residuals. The plot shows the cumulative sum of squared residuals together with two critical lines. If the cumulative sum goes outside the region between the two lines, the test finds parameter instability (Lilien et al. 1994).

Durbin Watson statistic

In time series regression, positive correlation of residuals which are adjacent in time is often a problem. The Durbin Watson statistic is a formal test for serial correlation. If there is no problem of association between adjacent residuals, the statistic will be around 2. With positive serial correlation, the Durbin Watson will fall below 2; in the worst cases, it will be near zero. Occasionally, negative serial correlation will occur, and the Durbin Watson statistic will lie somewhere between 2 and 4. Positive serial correlation is the principal hazard – with 50 or more observations and not too many independent variables, a Durbin Watson below around 1.5 is a danger sign (Lilien et al. 1994).

Exponential smoothing

This is a method based on a simple autoregressive statistical model. It does not make use of information from series other than the one being forecasted.

Heteroskedasticity

A key assumption of the Classical Linear Regression model is that the disturbance (or error) terms all have the same variance and are not correlated with one another. A key problem with the violation of this assumption in the model occurs with heteroskedasticity, whereby the disturbances do not all have the same variance (Kennedy 1992).

Jarque-Bera statistic

This statistic tests whether a series is normally distributed. Under the null hypothesis of normality, the Jarque-Bera statistic is distributed X2 with 2 degrees of freedom. It incorporates measures of skewness, (the relative thickness of the upper vis-a-vis lower tails of the distribution) and kurtosis (thickness of both tails relative to the normal distribution) (Lilien et al. 1994).

Negative relationship between variables

A negative relationship (or impact) between variables implies that the direction of change in a dependent variable will be inversely related to the change in the independent variable. That is, an increase in the independent variable will be associated with a decrease in the dependent variable. Alternatively, a decrease in the independent variable will be associated with an increase in the dependent variable. The size and significance of the coefficient indicates the strength of the relationship.

Positive relationship between variables

A positive relationship implies that the direction of the change in a dependent variable will be similar to that of the independent variable. The size and significance of the coefficient indicates the strength of the relationship. For example, Hitiris and Posnett (1992) found a strong positive relationship between per capita health spending and GDP. This implies that an increase (or decrease) in GDP will be associated with a similar increase (or decrease) in per capita health spending.

R squared

This measures the success of the regression in predicting the values of the dependent variable within the sample. R squared is 1 if the regression fits perfectly, and zero if it fits no better than the simple mean of the dependent variable. R squared is the fraction of the variance of the dependent variable explained by the independent variable. It can be negative if the regression does not have an intercept or constant if two-stage least squares are used (Lilien et al. 1994).

White heteroskedasticity test

This test examines whether the error variance is affected by any of the regressors, their squares or their cross-products. It tests for whether or not any heteroskedasticity present causes the variance-covariance matrix of the Ordinary Least Squares estimator to differ from its usual formula (Kennedy 1992). The output from the test is an F-statistic and a statistic which will have an asymptotic X2 distribution with degrees of freedom equal to the number of regressors and squared regressors in the test regression. Each statistic provides a test of the hypotheses that the coefficients of the variables in the augmented regression are all zero. This is a general test for model mis-specification, since the null hypothesis underlying the test assumes that the errors are both homoskedastic and independent of the regression and that the linear specification of the model is correct. Failure on any of these conditions could lead to a significant test statistic. Conversely, a non-significant test statistic would be very reassuring since it implies that none of the three conditions is violated (Lilien et al. 1994).

Notes

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