Casemix funding for a Specialist Paediatrics Hospital: A hedonic regression approach

JOHN F P BRIDGES AND RALPH M HANSON

John Bridges is Ph.D. Candidate in Economics, City University of New York Graduate School and Research Assistant, National Bureau of Economic Research, New York and Ralph Hanson is Director of Information Services, New Children's Hospital, Sydney.

Abstract

This paper inquires into the effects that Diagnosis Related Groups (DRGs) have had on the ability to explain patient-level costs in a specialist paediatrics hospital. Two hedonic models are estimated using 1996/97 New Children's Hospital (NCH) patient level cost data, one with and one without a casemix index (CMI). The results show that the inclusion of a casemix index as an explanatory variable leads to a better accounting of cost. The full hedonic model is then used to simulate a funding model for the 1997/98 NCH cost data. These costs are highly correlated with the actual costs reported for that year. In addition, univariate regression indicates that there has been inflation in costs in the order of 4.8% between the two years. In conclusion, hedonic analysis can provide valuable evidence for the design of funding models that account for casemix.

Introduction

Both in Australia and abroad there is a growing trend towards examining the determinants of hospital costs (Auditor-General of Victoria 1998 and Muldoon 1996). This trend can be explained by the need for hospitals to be accountable for their costs and through a desire to implement a funding system that creates incentives to further increase efficiency. For these purposes regression analysis has been an informative tool. Culyer et al (1978) were some of the first to use a simple regression analysis in a hospital setting, reporting a comparative study across British hospitals. They found a strong relationship between costs and the teaching load of the hospital. In Australia, regression analysis has been a valuable tool for identifying significant influences on hospital costs. Hindle, Degeling & van der Wel (1998) focus on within DRG variation of severity while using length of stay as a proxy for costs. Hindle, Frances & Pearse (1998) also analysed the cost structures of small rural hospitals using regression analysis.

Traditionally, one of the limitations of regression analysis has been the paucity of quality patient level cost data. However, with the emergence and implementation of more accurate cost-accounting systems, some hospitals now have a more accurate estimate of the resource cost of each individual patient. This type of data both allows for the use of more refined regression techniques and improves the performance of regression methods.

A regression analysis that relates costs to the various physical inputs is referred to as a hedonic regression. The hedonic method has been widely used in economics to analyse supply side variation in quality. It is often used in the analysis of real estate markets (Crosson et al 1996) and to distinguish between different qualities of other consumer goods (Byron and Ashenfelter 1995). The hedonic method is also used frequently in adjusting for quality aspects in consumer price indexes (Kokoski 1993). In health it has been used in the modelling of hospital costs across entire hospitals rather than across individual patients (Chernichovsky and Zmora 1986). Goldman and Grossman (1978) also used a hedonic approach to distinguish between the quality of paediatric care and the quantity of paediatric visits. In this paper, the hedonic approach is used to estimate patient level costs at a paediatric hospital through a number of observable factors including length of stay and casemix.

Analysis of New Children's Hospital (NCH) costs

The aim of this analysis was to inquire into the determinants of costs of patients admitted to the NCH using an hedonic regression approach. The analysis used all patients from the state of New South Wales (NSW) treated at the NCH in 1996/97, where patients were classified using AN-DRG version 3.1 (see Commonwealth Department of Human Services and Health & 3M Health Information Systems 1996). Exclusions from the analysis included patients that were part of the nationally funded program for liver transplants (DRG 5), patients from error DRGs (952, 955, and 956) and patients from costed but non-classified DRGs (locally referred to as DRG 999). Finally, all patients from DRG 780 (chemotherapy) had their costs adjusted to $640, the State wide paediatric benchmark set by NSW Health (1998a). After deletions there were 28, 282 observations.

The dependent variable is the estimated patient level cost reported by the New Children's Hospital. This estimated cost was calculated using a cost modelling technique that assigns costs to patients for the actual procedures that were performed. The costing methodology is derived and reviewed by NSW Health annually (see NSW Health Department 1996, 1997). For the purposes of this analysis, these reported costs could be considered as the gold standard for costs, as they are the best estimate of costs. The analysis will focus on the prediction of these costs using other available information about the patient. These other independent variables are outlined in Table 1.

Table 1: variables used in the analysis

Variable	Description
Cost	Estimated cost of separation
CMI	NSW 1996/97 casemix index (base weights)
LOS	Length of stay in days, same day patients given LOS = 0
Age	Age on admission in years
S.Day	Same day dummy variable, same day = 1, all other LOS = 0
Sec.diag	Number of secondary diagnoses (capped at ten, excluding V codes)
Emerg	Emergency dummy variable, admitted through emergency = 1, all other = 0
Trans	Transfer dummy variable, transferred in = 1, all other = 0
Rural	Rural dummy variable, rural area of residence = 1, other = 0
ATSI	ATSI dummy variable, Aboriginal and Torres Strait Islander = 1, all other = 0
Male	Sex dummy variable, Male = 1, Female = 2

Model one incorporates all explanatory variables excluding the casemix index. All variables were significant at the 1% level, except for the rurality variable which was significant at the 5% level (one tailed t-test) and ATSI, which was insignificant but of the expected sign (Ruben and Fisher 1998 and Fisher et al 1998).

Table 2: Comparison of hedonic regression models

	LOS	CMI	CMI & LOS	Model one	Model two
Intercept	220.42 (37.17)	213.19 (51.40)	-812.04 (33.91)	-306.84 (96.76)	-1673.00 (85.27)
CMI	N/A	2725.01 (21.69)	1501.48 (15.46)	N/A	1531.41 (15.96)
LOS	1074.44 (4.82)	N/A	895.24 (4.57)	1061.30 (5.26)	924.15 (19.15)
Age	N/A	N/A	N/A	-46.19 (7.65)	-12.57 (6.6)
S.Day	N/A	N/A	N/A	639.95 (81.96)	1479.58 (71.75)
Sec.Diag.	N/Aq	N/A	N/A	354.64 (21.76)	59.01 (19.15)
Emerg.	N/A	N/A	N/A	-734.46 (79.72)	-247.30 (69.45)
Trans.	N/A	N/A	N/A	3233.39 (186.61)	109.19 (165.38)
Rural	N/A	N/A	N/A	222.98 (126.37)	58.65 (109.82)
ATSI	N/A	N/A	N/A	281.19 (355.61)	138.33 (308.99)
Male	N/A	N/A	N/A	223.46 (70.92)	193.62 (61.62)
R2	63.62%	35.73%	72.70%	64.64%	73.31%

Length of stay is one of the most important predictors of resource use. Age is also an important predictor of cost, with younger patients having a higher resource cost (Hanson et al 1998). There is evidence to suggest that a same day admitted patient uses less resources than a patient with a stay of one day (overnight), this being consistent with traditional intuition that same day cases are less resource intensive.

Patients admitted through the Emergency Department (ED) had lower resource cost, holding all other variables constant. This runs against traditional logic that patients admitted through emergency stay are more costly. However, one should bear in mind that patients admitted through the Emergency Department have longer length of stay, are relatively younger and have more secondary diagnoses. It is these other variables that account for the higher costs of patients admitted through the Emergency Department.

Patients who are transferred from another hospital into the NCH cost significantly more than do other patients. Although this result is not counter-intuitive (Butt and Shann 1998), the magnitude of the result does attract interest. The demographic variables of patients are also important indicators of cost. Patients from rural areas are relatively more costly, as are male patients. Patients that indicated that they were from Aboriginal and/or Torres Strait Islander descent also cost relatively more. However, this result is statistically insignificant. The insignificance for Aboriginal and Torres Strait Islander dummy variable could be due to the low number of patients who identified themselves as of Aboriginal and/or Torres Strait Islander descent on admission to the hospital.

Model two extends upon model one by including a casemix index. The model uses the NSW 1996/97 "base weight index". NSW Health estimate "base weights" using trimmed data from the majority of hospitals in the state (see NSW Health Department 1998b). Model Two explains relatively more of the variation in costs than does Model One (R^2 = 73.31% as opposed to R^2 = 64.62%).

For model two the casemix index is highly significant in predicting the patient costs, but it is not the only significant variable. Length of stay is still a significant predictor of the cost of a patient. However, the estimate is not as large as in model one. Contrary to traditional logic same day patients are more resource intensive than patients with length of stay equal to one day (overnight), holding all other variables constant. Again, age is a predictor of cost, albeit at reduced statistical significance with younger patients costing relatively more. Cost also increases with the number of secondary diagnoses.

Patients admitted through the Emergency Department are relatively less expensive, but again the same caveats apply to the interpretation of this parameter as we presented for model one. Transfers are weakly more expensive in model two although, this coefficient is greatly reduced compared to that in model one. This evidence highlights that while transfers are more expensive, the great proportion of this cost can be explained through other explanatory variables.

Again, rural and Aboriginal and Torres Strait Islander patients are more expensive, but insignificantly so. Male patients are also more expensive. In hedonic regression analysis insignificant coefficients can improve the fit of the model and need not be eliminated from the model. This is especially the case when they possess intuitive signs.

Sensitivity analysis

The above models were assessed for possible spurious results. There was no evidence of significant multicollinearity and little evidence of heteroskedasticity, although there was a slight ballooning of variance at very high costs.

Caution was noted over the relatively small standard errors for LOS and CMI. The results indicated that these two variables are very strong predictors of costs. Using univariate analysis, LOS predicted 63.62% of the variation in costs and CMI 35.73% of the variation in costs. Together in a bivariate analysis, they predicted 72.70% of the variation in costs (Table 2). The fuller models are only marginally better in the prediction of the variation in costs (1.02% and 0.58% respectively for models one and two).

Simulation of 1997/98 NCH cost data

Model two was used to simulate the costs for NCH's 1997/98 financial year using patient level data to test its robustness as a funding model. As there had been a change in the NSW Health's costing standards, the 1996/97 methodology was used to estimate the reported costs of the patients for 1997/98. Again DRGs 5, 952, 955, 956 and 999 were removed from the data. DRG 780 was not modified. There were 27,916 observations used in the simulation.

The simulated costs from the full hedonic model were then compared to the reported patient costs for 1996/97. The correlation coefficient between the two was 0.88. Univariate regression yields the following:

Reported costs = 58.352 (30.711) + 1.048 (0.003) **Hedonic model**

R^2 = 78.00 (Standard errors in parentheses)

The intercept is marginally significant and the hedonic model is highly significant predictor of costs. The model had a good fit, with an R2 of 78.00% indicating it would be a potential funding model.

One of the problems with the model is that some simulated costs are estimated as negatives. One can consider that the minimum cost should be set at zero or some positive cost. If the minimum cost is set to zero the R^2 improves slightly to 78.04%, and if set to \$100 (an arbitrary cost) the R^2 is 78.06%. Alternatively one could use a more technical econometric specification such as using the log of cost as the dependant variable to avoid negatives.

Also one can interpret the estimate associated with the hedonic model as indicating inflation in costs between 1996/97 and 1997/98 of some 4.8%. This highlights that any funding policy needs to account for inflation in costs over time to be equitable.

Conclusions

NSW Health has developed its casemix index to incorporate a number of refinements beyond the standard concept of having an index that reflects the average costs (NSW Health Department 1998b). These include separate cost weights for same day, transfers (outward), long stay and private episodes. However, these refinements have been incorporated within the index and not added explicitly, as has been done in other funding models. To make adjustments more transparent, it would be better to estimate the casemix index with untrimmed data (base weights), and then derive a funding formula that incorporates the index. Hedonic regression - if applied to all patient level costing hospitals - could be a valuable tool in the formulation of such a funding model. It provides a powerful tool for understanding the factors that contribute to the variation in costs. Further research could include an analysis of all NSW hospitals that produce patient level costing data to estimate a funding formula for NSW based on the hedonic methodology.

References

Auditor-General of Victoria 1998, *'Acute Health Services Under Casemix: A Case of Mixed Priorities'*, Special Report No. 56, Victorian Government Printers, Melbourne.

Butt W & Shann F 1998, 'Transferred patients - more complex and more costly?', *Medical Journal of Australia*, vol 169, supplement, pp S42-43.

Byron R & Ashenfelter O 1995, 'Predicting the quality of an unborn Grange', *The Economic Record*, vol 71, no 212, pp 40-53.

Chernichovsky D & Zmora I 1986, 'A hedonic prices approach to hospitalization costs: the case of Israel', *Journal of Health Economics*, vol 5, no 2, pp 179-191.

Crosson S, Dannis C & Thibodeau T 1996, 'A cost-effective approach for the valuation of commercial property portfolios', *Real Estate Finance*, vol 12, no 4, pp 20-28.

Commonwealth Department of Human Services and Health & 3M Health Information Systems 1996, *'Australian National Diagnosis Related Groups Definitions Manual Version 3.1'*, 3M Health Information Systems, Connecticut.

Culyer J, Wiseman J, Drummond F & West P 1978, 'What accounts for the higher costs of teaching hospitals?", *Social and Economic Administration*, vol 12, no 1, pp 20-30.

Fisher D, Murray J, Cleary M & Brewerton R 1998, 'The Aboriginal and Torres Strait Islander Casemix Study', *Medical Journal of Australia*, vol 169, supplement, pp S11-S16.

Goldman F & Grossman M 1978, 'The demand for pediatric care; An hedonic approach', *Journal of Political Economy*, vol 86, no 2, pp 259-81.

Hanson R, Phythian M, Jarvis J, & Stewart C 1998, 'The true cost of treating children', *Medical Journal of Australia*, vol 169, supplement, pp S39-S41.

Hindle D, Degeling P & van der Wel O 1998, 'Severity variations within DRGs: Measurement of the hospital effects by use of data on significant secondary diagnoses and procedures', *Australian Health Review,* vol 21, no 1, pp 37-49.

Hindle D, Frances M & Pearse J 1998, 'Casemix funding in rural NSW: exploring the effects of isolation and size', *Australian Health Review*, vol 21, no 4, pp 174-189.

Kokoski M 1993, *'Quality adjustment of price indexes', Monthly Labor Review,* vol 116, no 12, pp34-46.

Muldoon J 1996, 'Paediatrics and DRG Casemix Classification' in Goldfield N & Boland P (eds), *Physician Profiling and Risk Adjustment,* Aspen Publishers, Gaithersburg Md, pp 252-270.

NSW Health Department 1996, 'Casemix standards for NSW 1996/97', Casemix Policy Unit, Structural andFunding Branch, NSW Health.

NSW Health Department 1997, *'NSW Costing Standards Manual Version 2.0',* Casemix Policy Unit, Structural andFunding Branch, NSW Health.

NSW Health Department 1998a, *'NSW Public Hospitals Comparison Data Book 1996/1997'*, Information and Data Services, NSW Health, Sydney.

NSW Health Department 1998b, *'NSW Casemix Standards 1998/99'*, Casemix Policy Unit, Structural & Funding Policy Branch, NSW Health, Sydney.

Ruben A & Fisher D 1998 'The Casemix system of hospital funding can further disadvantage Aboriginal Children', *Medical Journal of Australia,* vol 169, supplement, pp S6-S10.

Victorian Department of Human Services 1998, *'Victoria - Public Hospitals Policy and Funding Guidelines 1998-99'*, Department of Human Services, Melbourne.