School of Economics & Finance

Frontier Methods for Comparing Public Hospital Efficiency: The Effect of Casemix Funding in Victoria

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: ………………………………………………..

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Dedicated to my brother
Philip Mangano
1957-1998

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Chapter 1

Introduction

1.1 Aims and Background

This research examines the impact, if any, of the introduction of casemix funding on public hospitals in Victoria. The results reported here show that in Victoria, during the period under observation, rural hospitals showed a significantly greater preponderance, relative to metropolitan hospitals, to either amalgamate or close down. Since 1 July 1993 public hospitals in Victoria have been compared for efficiency in the delivery of their services. The casemix funding arrangements were installed, among other reasons, to improve efficiency in the delivery of hospital services. Duckett, 1999, p 107 states that under casemix funding 'The hospital therefore becomes more clearly accountable for variation in the efficiency of the services it provides'. Also, 'Generally, case-mix funding is seen as being able to yield efficiency improvements more rapidly than negotiated funding…'. Hospital comparisons provide State bodies with information on how to allocate funding between hospitals by means of annual capped budgets. Budgets are capped because funding is restricted to a given number of patients that can be treated in any given year. Thus, casemix funding relies heavily on cost comparisons between hospitals, and the way that hospital output is measured relies on the use of diagnosis related groups (DRGs).

DRGs identify groups of diagnoses that require a similar level of resources to treat a patient. This makes it possible for the cost of treating a particular diagnosis to be compared across hospitals. Historically this comparison was not possible since hospitals could claim that their casemix (i.e., the mix of conditions as classified) contained diagnoses that required more intensive use of resources, justifying higher costs. The DRG weights take these differences into account, since diagnoses that have a higher resource utilisation are attributed a higher DRG weighting. The use of DRGs makes it possible to measure and compare costs, since patients within the same DRG should consume similar amounts of resources. DRGs can be used, therefore, to standardise for differences in the casemix of hospitals and allow comparisons of hospital costs.

The aim of this work is primarily to use survivor analysis and production frontier techniques to assess the impact, if any, that the new funding regime had on Victorian public hospitals. Together with institutional evidence provided, this will show whether the Victorian State Government's objectives, one of which was to achieve increased hospital efficiency, were in fact realised.

There are several reasons why health reforms were undertaken in Victoria at this time. As far back as the mid 1980s Victoria's hospital system was being scrutinised in efficiency terms, with a view to introducing global funding. In early 1982 the Victorian Health Department had already gathered comparative data on cost per patient treated, adjusted for casemix using DRGs. Various reports published in the late 1980s concluded that hospital services in Victoria were inefficient. As a consequence, a Commission of Audit was appointed shortly following the 1992 State election. The Commission of Audit was charged with the task of reporting on State finances generally and, among its findings, concluded that Victorian acute hospitals were 18 per cent more expensive than hospitals in other States (Lin and Duckett, 1997, p 49). Findings from data published by the Commonwealth Grants Commission corroborated this finding by indicating that Victorian hospitals were relatively inefficient.

A further reason why reforms were undertaken in Victoria was that prior to the introduction of casemix funding, hospitals were funded annually on an historical cost basis. This was a perverse system that provided hospitals with increased budgets each year regardless of activity or productivity levels. Under this system there was an in-built incentive for hospitals to spend their full allocation of funds each year in order to secure a subsequent funding increase. This funding arrangement needed to be addressed, since it was held partly responsible for Victoria's debt blow-out which is outlined in section 1.2 below.

Hospital outputs are commonly referred to as separations. A separation is an episode of care following which the patient is either discharged or deceased; that is, it does not take into account patient outcome. The output measure used throughout this thesis is weighted inlier equivalent separations (WIES[1]), which account for DRG weighting. WIES are weighted relative to other separations. That is, each diagnosis carries a group weighting that ranks the average cost of treatment of the diagnosis relative to the average cost of treatment of other diagnoses. For instance, a simple endoscopy has a weight of 0.3, meaning that on average it costs 30 per cent of the cost of a diagnosis with a weight of one. Similarly, a liver transplant has a weight of 40. All discharged patients are coded to their correct group and allocated the appropriate group weight. Weights are then summed across all discharged patients to determine a hospital's casemix-weighted output or casemix-weighted number of cases discharged. The casemix may then be used to determine funding for the hospital by multiplying by the average cost of a diagnosis with a weight of one. For instance, if the average cost of a diagnosis with a weight of one is $2,400, the endoscopy would be priced at $720, while the liver transplant would cost $96,000. The cost of a diagnosis with a weight of one is known as the WIES (Johnson, et al., 2003).

1.2 Significance

The period 1992-93 to 1994-95 was characterised by a Victorian State debt in excess of $30 Billion (Victorian Budget Papers, 1999/2000, p 5). The newly elected Liberal coalition was committed to reducing this debt and so undertook expenditure cuts across many sectors. According to Duckett (1994), in its first year, 30 per cent of the total State budget reduction[2] was achieved solely by funding cuts to Acute Health. This was a considerably disproportionate reduction, given that Acute Health absorbs approximately 17 per cent of the State budget.

Budget cuts were thus implemented alongside the new funding regime, making it difficult for the news media in particular to distinguish between the two. Casemix funding received a considerable amount of negative press, which may partially explain why many other Australian States have hesitated in adopting similar hospital funding methods.

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[1] For a full description of WIES see section 2.4 in Chapter 2.

[2] By 1999/2000 State debt was reduced by over 80 per cent to $6.1 billion (Victorian Budget Papers, 1999/2000, p 5)

By 1998 New South Wales still did not fund hospitals on a casemix basis (Duckett, 1998). The other four States that had implemented casemix funding had done so by either adopting the Victorian model, or by using casemix to inform their budget setting process. South Australia’s model was adopted in 1994-95 and, though substantially modelled on the Victorian funding scheme, it made no distinction between payments for private and public patients. It also had access subsidies in place for very small hospitals in terms of prices charged. The new funding model was also accompanied by budget cuts in this State.

Western Australia and Tasmania implemented casemix funding in 1996-97. According to Duckett (1998) both States adopted the standard price capped, full price model that covers both fixed and variable costs. In the case of Western Australia, it has a block intensive care unit payment based on historical expenditure as well as payments for public and private patients also based on historical expenditure. In the case of Tasmania, casemix funding was only applied to the State’s three major hospitals.

Queensland began phasing in the casemix funding process in 1998. It adopted the Victorian model of standard price by hospital group, capped with fixed and variable payments separate. That is, the model involves a fixed grant for hospital overhead costs and a variable payment per patients treated. The model also has separate medical cost weights for medical payments for public patients (Duckett, 1998). It should be noted, however, that the adoption of the casemix funding model by these States does not necessarily correspond with its full adoption. In the case of Queensland, for example, Surrao et al. (2002) note that Queensland Health does not use casemix funding for its public hospitals, but uses casemix as a management and information tool. ‘Although casemix budgets are provided to public hospitals, these are used mainly to allow benchmarking and encourage performance improvement’ (Surrao et al., 2002, p 117).

1.3 Efficiency Measurement Methodologies

The frontier methods utilised in this thesis provide useful information for comparing the performance of hospitals in terms of their relative efficiency. Efficiency in production can be viewed in two ways; technical efficiency and allocative efficiency. Technical efficiency is attained by either maximising output for given inputs, or producing a given output with fewer inputs or at a lower cost. Allocative efficiency ensures that resources are devoted to the combination of goods and services most wanted by society (Jackson and McIver, 2004). The analyses in this thesis provide efficiency measures of the former type.

The frontier methods used in this thesis estimate a technical efficiency score for each hospital under observation. Since hospitals provide services of varying intensities, the output chosen must be weighted in such a way to standardise outputs and enable comparison of input usage. This is the reason why weighted separations have been used to measure output, and not inpatients treated or separations. Both frontier techniques relied on in this thesis compare the technical efficiency of hospitals based on their number of WIES. It is clear that, although hospitals cannot control the rate at which patients present themselves for treatment, they have some influence over the amount of resources applied to patient treatment and recovery.

The frontier techniques used are Data Envelopment Analysis (DEA) and Stochastic Frontier Estimation (SFE). DEA is a non-parametric mathematical programming approach that envelopes the data such that the most efficient firms under observation form a frontier, to which all other firms are compared. The DEA technique can estimate production and cost frontiers. In this thesis DEA has been used to construct production frontiers, since cost frontiers require accurate price data, which was unavailable for the purpose of this study.

SFE is a parametric modelling technique that estimates a frontier but does not *derive* the frontier from the data, as is the case for the DEA model. The fact that the frontier is *estimated* means that no firm will achieve a perfect technical efficiency score equal to 1. Firms are compared for their *relative* efficiency, rather than any absolute measure of efficiency, or benchmark, as generated by DEA. SFE with a decomposed error term is also able to separate statistical noise from technical inefficiency. This technique can be used to produce cost and production frontiers but, for reasons provided in the previous paragraph, only production is addressed in this thesis.

1.4 Outline of Chapters

Chapter 2 sets out a review of the literature that informs this thesis. It contains literature on the issue of hospital funding, such as reimbursement schemes and casemix funding; its history and application. The review also considers the issue of new technology on hospital costs, adverse selection and moral hazard effects resulting from reimbursement systems, and efficiency measurement applied to hospitals. Chapter 2 also considers literature that addresses health sector reform in Victoria and in Australia generally. Chapter 3 provides detail on the three methods in this thesis that are applied to Victorian data; survivor analysis, DEA and SFE, their strengths and weaknesses.

Chapter 4 contains information on the Australian healthcare market, why government intervention is necessary in health, an overview of the development of funding arrangements in Victoria, and the Victorian health system and its structure. In particular, the operations of the Acute Health sector are examined, together with health reforms in that State, and the application of AN-DRGs. This chapter also presents evidence on total health expenditure in Victoria, together with the number of hospitals that existed during the timeframe under consideration. There is also an appendix to this chapter that sets out hospital specific data for WIES, inpatients treated, non-medical staff and average available beds for Victorian hospitals for each of the four years under consideration. Summary tables of this data are also contained in this chapter, and enable comparison and analysis.

Chapter 5 examines economies of scale and analyses their existence in the sector for public and private hospitals in Victoria and Australia. The survivor technique is applied by grouping hospitals into size according to average available beds, and then comparing the change in each group's market share over time. Market share is measured with average bed days. This chapter also sets out the amalgamation and closure activity of public hospitals that took place in Victoria between 1991/92 and 1995/96. This activity is shown to have occurred mostly among small rural hospitals, as a consequence of difficulties experienced under the output based funding system in place.

Chapter 6 contains two Data Envelopment Analyses, one under the assumption of constant returns to scale, and the other under the assumption of variable returns to scale. Both sets of results are also outlined, with overall technical efficiency scores showing a slight improvement over time. The results show that prior to closure hospitals tended to be poor performers in terms of their relative position to the frontier. As the DEA frontier improved over time, it is apparent that there was room for improvement even among the technically efficient hospitals at the beginning of the period under observation.

Chapter 7 estimates a parametric SFE technique with decomposed error term showing technical inefficiency effects, and which uses panel data of 116 hospitals over a four year period. The results show that metropolitan hospitals and teaching hospitals both lower the technical inefficiency effect. These results are compared with the DEA results, and show that there was no significant improvement in technical efficiency over the period under investigation. Concluding comments are contained in Chapter 8.

Chapter 2

Literature Review

The literature that forms the basis of this thesis is varied. There exists abundant literature on incentive effects of hospital reimbursement schemes and casemix funding, a discussion of which is outlined in section 2.1 below. Other relevant papers deal with the application of SFE and DEA methodologies to hospitals and healthcare markets (section 2.2) as well as general applications of DEA and SFE (section 2.3). Section 2.4 provides a review of the literature dealing with Australian and Victorian healthcare issues, and section 2.5 outlines some findings regarding hospital mergers. Coelli (1996^a) and Coelli (1996^b) provide the DEA and SFE computer programs used, and Chambers (1997) details duality in production and explains the mathematical process involved.

2.1 Incentive Effects of Hospital Reimbursement

In order to analyse the effects of casemix funding in Victoria, it is necessary to firstly identify the issues that arise when policymakers decide to reimburse hospitals according to some pre-specified requirement or incentive. Clearly the choice of reimbursement scheme will impact on hospitals' provision of healthcare services depending on how the incentives are structured. There currently exists significant literature that addresses hospital reimbursement incentives which purports to measure their degree of success.

Public funding incentives for hospitals are necessary in order to prevent over-use of costly resources that, it may be considered, provide little improved benefits. Although innovation and new technologies reduce costs in most markets, it is the reverse for the services sector in general and hospitals/healthcare in particular. Some of the findings are summarised below [see Rice (1998), Newhouse (1993), Pauly (2005), Weisbrod (1991) and Bodenheimer (2005) for a comprehensive discussion of the effect of new technology on health expenditure].

According to these authors, in the longer term, the adoption of new technologies by hospitals results in increasing costs. Rice (1998) argues that this is partly due to the fact that people come to expect new technologies and so demand more. Newhouse (1993) argues that the main cost driver of healthcare in the US, and other developed economies, is new technology and its ability to increase the capabilities of medicine. Newhouse makes the distinction between the level of healthcare spending as a percentage of GDP, and the rate of growth of spending. He challenges the widespread view that healthcare expenditure in the US has grown at a greater *rate* than other developed economies. Newhouse (1993) shows that the main reason that healthcare expenditure, as a percentage of GDP, has grown over time is due to people's willingness to pay for new technologies, and that this phenomenon is not restricted to the US. Given this finding, the upshot for managed competition is that '…[It] will not, apart from a transitory period, slow the rate of increase in medical care costs' (Newhouse, 1993, p 165). Cost-containment of new technology (and its rate of growth) is, therefore, central to the discussion of incentive effects of hospital reimbursement schemes since, as the literature bears out, there is a close link between treatment choice, available technology (which increases medical capabilities) and costs.

McClellan (1997) discusses the Prospective Payment System (PPS), which uses fixed payments based on the diagnosis-related group (DRG) of a hospital admission in the U.S. Indeed, according to McClellan, the PPS was implemented to provide stronger incentives to minimise spending on costly technologies that generates little expected benefit. In terms of incentives, this paper posits that in the US reimbursement incentives are not the same across diagnoses, demographic groups and types of intensive treatments. That is, reimbursement is only partially prospective. Increasingly, some reimbursement is made retrospectively. McClellan also discusses cost sharing. This is defined as the degree to which hospitals share the reported costs of production with the payer. By way of explanation, the removal of cost sharing leads to supply-side moral hazard. That is, if hospitals receive a dollar reimbursement for a dollar of increased costs, there would be less incentive on their part to minimise resource use.

Given this scenario, McClellan (1997) finds that over 40 per cent of DRGs are related to the performance of procedures rather than the actual diagnosis. That is, there is a positive relationship between the actual cost of procedures undertaken by a hospital and the amount of reimbursement received.

> Payments for these specific intensive procedures are consequently based on the average cost of patients undergoing the procedure rather than all patients with a particular associated diagnosis. By performing the procedure, the hospital incurs higher costs but also obtains more reimbursement. (McClellan, 1997, p 93).

McClellan's finding of this positive relationship thus defeats the purpose of the incentive scheme, which was designed to minimise the use of costly technologies. Clearly, the higher the cost of the intensive procedure (eg. coronary by-pass surgery), then the higher is the reimbursement. Indeed McClellan (1997, p 93) notes that this treatment-based payment system would '…encourage investments in expanding the use of certain kinds of medical technologies, particularly those singled out for separate reimbursement'. By passing on the costs of more intensive treatment, hospitals are encouraged to continue purchasing new technology, leading to patients being treated more intensively.

McClellan's (1997) findings show that retrospective cost sharing of intensive treatment is increasingly enabled by the PPS. At the end of the period of observation the author finds that an additional dollar of reported cost is associated with 55 cents additional reimbursement, and that '…more than half of this additional reimbursement was related to treatment decisions rather than fixed characteristics of an admission' (McClellan, 1997 p 94).

The situation of increased retrospective reimbursement arises because of the fact that over 40 per cent of DRGs are treatment-related and not solely based on diagnosis. Patients within a diagnosis may be treated in a number of ways ranging from medication to surgery. Treatments by medication tend to have low DRG weightings (less than or equal to 1), and surgical treatments have DRG weightings greater than 1. McClellan notes that these DRGs (with higher weights) are more likely to represent more intensive treatment options available. That is, they represent invasive surgical procedures made possible by costly medical technology. The higher is the

DRG weight, the higher the level of retrospective cost sharing and reimbursement (McClellan, 1997).

Another important issue raised by McClellan (1997) is that DRGs based on diagnoses alone do not provide information about the true cost of treatment. That is, retrospective features were incorporated in the PPS because not all intensive procedures (and therefore patient costs) can be identified prospectively. It is not always certain at the time of admission to what degree a patient will be treated, even after initial diagnosis. For this and other reasons, the incentive effects of the PPS remain uncertain.

> The complexity of the reimbursement system suggests that the magnitude of the limits on cost sharing, and the extent to which it is actually prospective, are not well understood, and so the incentive effects of PPS may not be fully appreciated.
> (McClellan, 1997, p 101).

McClellan's empirical analysis of reimbursement incentives within PPS provides some new insights. The author finds that the average cost-sharing rate falls by approximately 0.08 due to the prospective part of PPS. The reduction in cost-sharing rate rises to 0.16 or more due to the retrospective part of reimbursement associated with specific intensive treatments (McClellan, 1997, p 125). Although this analysis does not tell us anything about responses to incentives, it does provide a means to measure reimbursement incentives. Clearly the rate of technological change has a significant impact on the extent of retrospective cost-sharing, and the author acknowledges that a proper understanding of the complexities of the PPS may lead to a deeper understanding of reimbursement incentives on hospital treatment decisions.

Gilman (1999) challenges McClellan's (1997) use of endogenous costs in the model as problematic, and analyses the potential effects of using endogenous costs on McClellan's cost-sharing model results. As a result of this analysis Gilman finds that '[e]ndogenous shifts in non-payment-related services…will underestimate increases in cost sharing. Endogenous shifts in payment-related services…can cause either over- or under-estimation of cost sharing' (Gilman, 1999, p 451). Furthermore, 'in the case of the HIV-related DRG refinements implemented by New York Medicaid in 1994, McClellan's model caused the cost sharing incentives to be overestimated' (Gilman, 1999, p 451).

Pauly (2000) addresses the issue of supply-side reimbursement, where the existence of health insurance may give rise to moral hazard. The author notes that one way to prevent, or lessen, the existence of moral hazard is to introduce cost-sharing, as is the case with co-insurance. Pauly argues that requiring patients (insureds) to make some percentage payment of an approved charge, '…gives providers an incentive to be technically efficient…' (Pauly, 2000, p 545). This is because providers compete by charging a fee that is sufficiently low to attract price-sensitive patients.

In the case of service benefit insurance where benefits are stated in physical terms, such as providing insurance for a private hospital room, for example, Pauly (2000) discusses the reimbursement incentives regarding upper limits. Insurers are able to set per unit upper limits to a particular charge in order that patients search for providers that charge the lowest price for a particular service. Providers would, likewise, seek out price-sensitive patients by competing on price. This argument overlooks the fact that in highly concentrated geographical markets with few providers, such as rural areas, patients may find little or no difference between prices charged and, therefore, face much higher out-of-pocket expenses as a result of upper limits to reimbursement.

Pauly (2000) also discusses the link between accounting cost reimbursement, and productive inefficiency. Where reimbursement is made dollar for dollar for costs, there is no incentive for hospitals to minimise costs. The price or quantity of inputs need not be altered since, regardless of input levels, profits would not be affected. The author proposes that the best way to offer an incentive to minimise costs is to base reimbursement on outputs and pursuant to some price schedule. However, using a price schedule gives rise to the problem of having to define services.

Another issue that affects reimbursement incentives is that patients are not homogeneous. Pauly (2000) posits that this will have an impact on the quality of treatment received by patients because fully prospective payments, in particular, do not allow for differing severity of illness. The insurer will base reimbursement on the average cost to treat a patient with a given illness, but patients are heterogeneous and severity varies from case to case. The incentive, in this case, would be to either under treat or dump high cost patients, once hospitals have determined that severity of illness is above average (Pauly, 2000). Pauly states that since the information regarding severity is not known on admission, but gained over time during the hospital stay, it is not necessary for insurers to make a marginal payment for sicker patients on admission. However, patient dumping (usually onto the public system) can be avoided by providing an incentive payment later on in the admission once severity is known. This strategy by the insurer would result in a mixed payment system.

Pauly (2000) acknowledges that supply-side reimbursement is limited in its ability to control moral hazard. The issue is made complex due to the existence of asymmetric information and variable treatment quality (depending on severity) resulting from fixed price reimbursement. He posits a combination of fixed and variable payments, with adjustments for quality and quantity to achieve at least a second best optimum.

Similarly, Ellis (1998) addresses the issue of reimbursement effects on treatment decisions. In particular he examines the effect of payment incentives on creaming, skimping and dumping of patients by hospitals. The author defines creaming as over-treatment of low severity patients, skimping as under-treatment of high severity patients, and dumping as the explicit avoidance of high severity patients. The hospital response in terms of how patients are treated is a function of the type of incentive structure in place; fully prospective payment, traditional cost-based or mixed payment. The prospective payment system, such as Medicare in the U.S., provides a lump sum payment per patient in a given DRG at the time of discharge regardless of the level of services provided. Intuitively, we would expect hospitals to over-treat low severity cases, and skimp or dump high severity patients under this system (as the reimbursement could be insufficient to cover the true cost of treatment). The model utilised by Ellis (1998) shows that this is, in fact, the case.

Under the cost-based reimbursement system the model shows that hospitals '…provide services up to the point where marginal benefit is zero, and "cream" to attract all types of patients' (Ellis, 1998, p 549). This system encourages providers to compete to attract patients even though the benefits of treatment may not exceed the costs. Prospective payment reimbursement reduces the intensity of services provided relative to cost-based reimbursement, but exacerbates the incentive for insurers to compete to attract low severity patients. Under this system Ellis finds that if dumping occurs, and hospitals avoid high severity patients, then skimping also occurs. However, in the case of the mixed payment method Ellis shows, using comparative statics, that there is a 'third best' solution superior to the fully prospective or fully cost-based systems.

> …and movements away from a fully prospective system appear to be welfare improving.
> (Ellis, 1998, p 553).

Indeed Ellis (1998) provides the theoretical underpinnings for an earlier paper by Ellis and McGuire (1996) that developed a panel data model to disentangle the effects from changed reimbursement. That is, Ellis and McGuire (1996) address the issue of how hospitals altered their patient mix, treatment intensity or even market share according to how they are reimbursed following the introduction of U.S. Medicare in 1983. The issue of moral hazard emerges from the differing levels of treatment intensity (referred to as creaming and skimping by Ellis, 1998) for any given patient. Change in patient mix is termed 'selection' effect, and market share change is termed 'practice-style' effect since it has an impact on average resource use across hospitals.

In the two years following the introduction of Medicare, the average length of stay per discharge fell sharply for hospitals paid under PPS. Also, the total number of discharges fell for this group, with market share for non-PPS hospitals rising (Ellis and McGuire, 1996). Since these effects all impact on one another, it is difficult to attribute the reduction in length of stay solely to moral hazard. Therefore, the authors use a natural experiment to examine the changes in treatment patterns in New Hampshire following a change in reimbursement system from cost-reimbursement to a per-discharge payment according to DRG. The results show an overall reduction in length of stay of 4.5 days. The authors attribute 1.8 days to pure moral hazard effect, and 3 days to practice-style effect.

In 1994 Medicaid in New York switched from a system based on patient characteristics to one based on a refined set of diagnoses and procedures (defined over treatment decisions). A later study by Gilman (2000) extends the analysis to this second generation of DRGs. Under the new Medicaid system, the weights given to procedural DRGs increased, and the weights to non-procedural DRGs fell. Using the group of HIV-related DRGs, Gilman (2000) shows (in Table 2 of that paper) that on average procedural DRG weights rose from 0.95 to 1.42, and non-procedural DRG weights fell on average from 1.62 to 1.10. Overall, however, HIV-related DRG weights fell from 1.49 to 1.12, a considerable reduction in average reimbursement and profitability. The consequences of this policy change, in terms of hospital response, are analysed by the author. Specifically Gilman decomposes '…the overall impact of PPS refinements on hospital resource use into its selection and moral hazard effects, including both its marginal and its average reimbursement incentive components' (Gilman, 2000, p 279).

Using a modified version of Ellis and McGuire's (1996) model, Gilman (2000) shows the changes in length of stay and severity of both procedural and non-procedural DRG patients due to both moral hazard and selection effects (Table 6 in Gilman, 2000). With a reduction in severity, length of stay fell for non-procedural and procedural DRGs (-1.19 and -3.34 days respectively). This is termed the 'selection effect'. For moral hazard effects, the average reimbursement incentive component led to a reduction of 3.32 days in average length of stay for non-procedural, low priced patients, and an increase of 1.06 days for high priced, procedural patients. The total effect of the average payment incentive components was a reduction in length of stay by 2.75 days.

The author also shows that the marginal reimbursement incentive component of the moral hazard effect resulted in an increase in length of stay of 0.42 days for all HIV-related DRGs. The net effect, taking into account moral hazard and selection effects, was a reduction in length of stay of 3.91 days for all HIV-related DRGs. From these results it is clear that the marginal reimbursement component has only a minor impact on length of stay and resource use. It is also evident that hospitals increased the intensity of services provided to procedural patients and decreased services to non-procedural patients (a shift from medical to surgical forms of treatment), resulting in lower average severity of both types of patients (Gilman, 2000).

2.2 DEA and SFE - Applications to Hospitals/Healthcare

This thesis examines inefficiencies in hospital service delivery in Victoria using both parametric and non-parametric frontier methods. Data envelopment analysis (DEA) is non-parametric and involves the use of linear programming methods to construct a frontier over the data so that each firm's performance can be compared to this frontier (Coelli, 1996^{b}). Work on modern efficiency measurement began with Farrell (1957) who drew upon the work of Debreu (1951) and Koopmans (1951) to define a simple measure of firm efficiency that could account for multiple inputs under the assumption of constant returns to scale. Banker, Charnes and Cooper (1984) advanced the original work by accounting for variable returns to scale. The refined stochastic frontier production function (SFE) is parametric, and was independently proposed by Aigner et al. (1977) and Meeusen and van den Broeck (1977), Battese and Corra (1977), and refined by Jondrow et al. (1982). This technique was initially developed for use as a cross-sectional approach to measuring inefficiency until it was further modified to allow for the use of panel data (Schmidt and Sickles, 1984). Both of these techniques have been applied to hospitals and other healthcare organisations, as is borne out by the ensuing discussion.

Zuckerman et al. (1994) use a cross-sectional stochastic frontier multiproduct cost function to derive hospital-specific measures of inefficiency. The authors recognise that one of the goals of Medicare's PPS in the United States is to '…promote efficiency by rewarding hospitals that are able to keep their costs below PPS rates and penalizing those that are not' (Zuckerman et al., 1994, p 256). They also observe a wide range of profitability among hospitals in 1990, which they attribute in part to the changes in the way that hospitals are paid. The existence of high profits for some hospitals and losses for others, leads the authors to question whether profitable institutions are efficient, and those experiencing losses are not. If this is the case, it follows that inefficient hospitals should cut their costs and profitable hospitals should expand production (Zuckerman et al., 1994). Their stochastic frontier model measures the relative efficiency of hospitals so that they can better assess the relationship between profits and efficiency, thereby providing an answer to this question.

Among their findings, the authors conclude that inefficiency '…accounts for 13.6 percent of total hospital costs' (Zuckerman et al., 1994, p 255), and that the PPS, which rewards efficiency and penalises inefficiency, provides '…hospitals with appropriate incentives' (Zuckerman et al., 1994, p 275). This is because a reduction in inefficiency reduces costs. Their model shows that by removing the 13.6 percent estimated inefficiency this would have reduced hospital costs in the U.S. in 1991 by approximately $31 billion (Zuckerman et al., 1994, p 274). The findings also indicate some specific relationships with inefficiency.

Firstly, the model shows that there is a negative relationship between profitability and inefficiency, with profit rates significantly higher among relatively less inefficient hospitals (Zuckerman et al., 1994, p 272). Furthermore, hospital occupancy rates are inversely related to inefficiency. An increase in occupancy is related to lower inefficiency and lower costs in the industry. Following on from that finding, therefore, a reduction in productive capacity of the average hospital, as well as a reduction in the number of hospitals per population, could reduce inefficiency (Zuckerman et al., 1994). With regards to the degree of competition in the market, the findings show '…weak evidence that competition from other hospitals is related to inefficiency' (Zuckerman et al., 1994, p 272). As expected, the authors find a positive relationship between average salaries paid and inefficiency. They note that this could be due to the fact that there are differences in the qualifications and mix of nursing staff, for example, employed at different hospitals. Despite the advantages of employing higher quality staff, the results would indicate that hospitals that pay higher average salaries are inefficient. This issue of quality difference is also relevant to the number of staff per adjusted admission. The findings show a positive relationship between staff numbers, quantity of assets (intensity of input use), and inefficiency.

This issue of quality of care is dealt with by the use of 30-day post-admission Medicare mortality rates and board certification of medical staff. The authors acknowledge that quality is difficult to measure and they do not present their results as conclusive proof of their findings. In particular the authors examine the relationship between quality of care and inefficiency. In relation to this, the findings show that '…the least efficient group of hospitals is not staffed by a more highly board certified staff nor is it achieving a lower observed-to-expected mortality rate ratio than the most efficient group' (Zuckerman et al., 1994, p 273). This finding would imply that inefficiency is not associated with higher quality healthcare.

Their cost function, which relies on maximum likelihood estimators (MLE), includes direct measures of illness severity, output quality and patient outcomes to reduce the likelihood that the inefficiency estimates are capturing unmeasured differences in hospital outputs. In relation to output endogeneity, although the authors reject this hypothesis they do treat one output, namely inpatient days, as endogenous.

The motivation for Zuckerman et al. (1994) is that other studies of hospital efficiency estimation apply the DEA method, and many consider that method to be inferior to the stochastic frontier. Hofler and Folland (1991) [as cited in Zuckerman et al. (1994)], for example, note that the DEA, which estimates a deterministic frontier, does not necessarily identify truly efficient benchmarks in the data.

> As Hofler and Folland point out this is not entirely satisfactory because it assumes that some observed production process (or combination or processes) is efficient, while ignoring that the observations in any data set may be subject to random fluctuations.
> (Zuckerman et al., 1994, p 258).

This is particularly problematic when estimating cost functions, as it is not possible to establish what is the appropriate level of minimum costs, i.e. the benchmark. The stochastic frontier relaxes the implicit structure embodied in DEA, and allows the model to identify deviations from the frontier that are not due to a hospital's behaviour and, therefore, out of their control (Zuckerman et al., 1994). These deviations could be the result of unusually high rates of a particular illness or unexpected expenditures on plant and equipment, and could be misinterpreted as inefficiency. Despite the obvious thoroughness of this paper, Skinner (1994) challenges the use of stochastic frontiers with cross-sectional data for hospital efficiency measurement.

Skinner (1994) presents an argument based on the efficacy of basing policy decisions involving 'millions of dollars' on a statistical assumption. Specifically, Skinner considers two scenarios; one where the stochastic frontier finds inefficiency where there is none, and one where it fails to distinguish inefficient from efficient industries either statistically or visually. The argument is based on the accuracy of the error term of the cross-sectional stochastic frontier model, which is decomposed into noise and inefficiency. In the first instance the occurrence of a random event that happens, for example building repairs, every 5 years, and that gives rise to increased costs, may be misinterpreted as inefficiency prevailing in an industry. The use of panel data (a number of years of observations for a number of hospitals) would overcome this problem since the occurrence of a random event would not affect the results to any great extent. Secondly, Skinner (1994) notes that the distribution of noise and that of the total error term are visually not significantly different from each other, leading him to question whether policy recommendations involving health expenditure can be based on such an error term.

Skinner (1994) contends that a non-parametric DEA frontier model with panel data yields more robust estimates of cost differences among nursing homes or hospitals. It is Skinner's view that the use of panel data will allow researchers to estimate a fixed effect for each health facility. The author, therefore, prefers the non-parametric approach taken by Kooreman (1994[a]) in the same volume, notwithstanding the fact that it too uses cross-sectional data.

In his study, Kooreman (1994[a]) analyses the technical efficiency of Dutch nursing homes with respect to the use of labour inputs using the DEA production function technique. The data is based on a survey held in 1989 among all 320 nursing homes in The Netherlands. Missing observations for some homes reduce the sample to 292 homes. Kooreman states that an important advantage of DEA, in addition to not having to pre-specify a functional form for the production function, is that it is relatively easy to handle the case of multiple inputs and outputs. However, the author also states that DEA is a *relative* efficiency criterion. DEA does not detect inefficiency of the nursing home sector as a whole, but rather the performance of nursing homes relative to the sector's best performers.

Kooreman (1994^{a}) differs from previous studies of the nursing home industry in that he estimates a primal production function whereas others estimate cost functions. He posits that technical efficiency is a prerequisite for cost efficiency, so it stands to reason that the technical efficiency estimates of the production function will also provide useful insights of cost efficiency in the nursing home industry. Another notable difference is that his data is taken from The Netherlands, whereas others use U.S. data.

The nursing home industry in The Netherlands is financed on the basis of prospective payments for the number of beds, treatment days and capital costs. The budget allocated to a nursing home may result in a surplus, which is available to the home for future expenditure (Kooreman (1994^{a}). The system is regulated in that there is very little scope for a nursing home to select patients; rather an 'indication committee' of health care experts allocates patients to homes. This point alone makes any comparisons to the hospital sector rather weak since, in the former case, budgets are based on historical cost with no apparent incentives built in to the payment system to encourage technical efficiency. Nevertheless, the results are topical and relevant to the application of DEA in healthcare, and are reported here.

Kooreman (1994^{a}) shows that the nursing home sector operates under constant or decreasing returns to scale. According to this assumption, the results also show that an unusually high number (50 percent of nursing homes) operate on the technically efficient DEA frontier (Kooreman, 1994^{a}, p 309). The stricter efficiency criterion of constant returns to scale produces a frontier with 21 percent of nursing homes operating efficiently. Since the constant or decreasing returns criterion eliminates the effects of size of home from the efficiency estimates, the author proposes that this one is more appropriate. In any event, the existence of government regulation reduces a home's ability to determine its own size (Kooreman, 1994^{a}).

There is a second stage to Kooreman's analysis, which examines the characteristics of efficient nursing homes so that the causes of inefficiency can be identified. The author uses censored regression models, however he acknowledges that these models produce '…estimates that are asymptotically biased toward zero…' (Kooreman, 1994^{a}, p 310). The size of the nursing homes is explained using the number of beds, the number of beds squared, and the presence of day care facilities. The equation used (constant and decreasing returns), however, measures efficiency conditional on a given size, and eliminates size effects. The author notes that a high occupancy rate would be translated into higher efficiency even though it could also be an indication of poor quality. This is because if the demand for beds increases suddenly, the inputs required (e.g. nursing staff) cannot be increased quickly. The efficiency score will improve because the ratio of inputs to outputs falls. Therefore, quality of care is inversely related with efficiency since higher quality requires more inputs for a given output level. The author includes quality variables such as presence of a patients' council, presence of a council of patients' relatives, presence of a procedure for handling complaints and a variable that indicates the absence of visiting hour restrictions, in order to determine this relationship (Kooreman, 1994[a]). The author also notes that the various care requirements of patients in nursing homes will determine the level of resource requirements. Volunteer staff provides some of these activities, and this would result in lower inefficiency. The author also controls for age of patients since, generally, older patients require more resource use. The results show that on average non-efficient homes use 13 percent more labour inputs per unit of output compared with efficient homes (Kooreman, 1994[a]).

However, Dor (1994), in reviewing the DEA and SFE techniques, observes that DEA does not include a stochastic error term. He states that in practice all random noise in the DEA is combined with the true inefficiency, resulting in suspect inefficiency scores. The SFE method, conversely, has an advantage over DEA in that it separates the two sources of error. Although Dor prefers the technique used by Zuckerman et al. (1994) outlined above, he acknowledges that an improved method would be to use panel data.

Dor's (1994) criticism of Zuckerman et at. (1994) is aimed at their use of cross-sectional data, and the necessary reliance on maximum likelihood estimators (MLE). MLE have omitted variable problems in that omitted variables appear as inefficiency. Panel data estimators are preferable because they '…are less likely to yield biased estimates of the βs due to omitted variables, and because they require fewer distributional assumptions about the deterministic error (u_i)' (Dor, 1994, p 332). Another reason for using a panel data approach is that it allows the analyst to test for endogeneity of outputs directly, rather than having to cross to the ordinary least squares model and then back again to the SFE, as is the case in the cross-sectional approach taken by Zuckerman et al. (1994).

Newhouse (1994) looks at frontier estimation in health care and concludes that such estimates cannot be relied on when trying to apply these measures of efficiency to reimbursement decisions. He states that the major difficulty is the measurement of output, which tends to be measures of patient days or stays. According to Newhouse, the generic problem is the variation in quality of the product and its dimensionality; frontier techniques, in his opinion, work best when the product is homogeneous and one-dimensional. Newhouse (1994) addresses the use of frontier estimation as generic, without acknowledging the strengths and weaknesses of both techniques and the different results obtained from both cross-sectional and panel data. He notes that omitted inputs appear as inefficiency, but this is only the case for the SFE using cross-sectional data. He also attributes differences in severity of illness between hospitals as being mistaken for differences in efficiency since the resources required for treatment also differ. It is possible to some extent to overcome this problem by using DRG weighted separations as measures of outputs.

Kooreman (1994[b]), in reply to Dor (1994), Skinner (1994) and Newhouse (1994), suggests that DEA and SFE are complementary tools because each addresses a different question. DEA uses input and output quantities to determine the level of technical efficiency, and SFE uses input prices, output quantities and total costs to determine both technical and allocative efficiency. According to Kooreman the strengths of both techniques can be demonstrated in future research by using panel data. He agrees that DEA and SFE results should not be simplistically taken to determine hospital reimbursement levels. However, the fact that policymakers may prematurely base reimbursement decisions on the results of these methods '…does not impair the usefulness of DEA and SFE as descriptive and analytical tools' (Kooreman, 1994[b], p 346). The use of these methods and the results they produce, therefore, provide a mechanism for identifying hospitals where special circumstances have given rise to differences in efficiency scores. The author posits that once this is known, it is possible for policymakers to investigate those hospitals more closely before deciding on whether or not the hospital is operating inefficiently. 'Thus, in my view DEA and SFE primarily serve as signal devices' (Kooreman, 1994[b], p 346).

Following on from the above debate in 1994, another paper published in the same journal in 1998 uses both techniques. Linna (1998) investigates the development of hospital cost efficiency and productivity in Finland in the period 1988-1994 by comparing both parametric and nonparametric panel models. The parametric panel methods use stochastic cost frontier models with a time-varying inefficiency component. The nonparametric panel methods use various DEA models to calculate efficiency scores and the Malmquist productivity index.

Linna's main objective in undertaking this study was to determine if the use of panel data models would improve the estimates of individual efficiency scores compared to earlier cross-sectional analyses. The author finds that results using panel data suggest that a reduction in inefficiency will reduce total hospital costs by between '…1.0 [and] 1.2 billion Finnish marks annually' (Linna, 1998, p 425). These figures are slightly lower than those obtained using cross-sectional models, however the author notes that it is difficult to measure the significance of reliability improvement from cross-sectional data to using a panel. The results further indicate that the choice of modelling approach does not affect the results. SFE and '…DEA models were both able to reveal that productivity progress in 1988-1994 was due to both the exogenous rate of technical change and to the effect of time-varying cost efficiency' (Linna, 1998, p 425). The author finds, however, that SFE and DEA methods produce different average efficiency scores. Nevertheless, he concludes by saying that nonparametric and parametric methods used together with panel data provide a sufficiently clear understanding of the development of efficiency in hospital production to justify future studies of frontier models in health care.

In an earlier journal issue of the same year Puig-Junoy (1998) uses a cross-sectional DEA to examine technical efficiency among Intensive Care Units (ICUs) in Catalonia (Spain) using a two-stage approach. In the first stage environmental factors, over which the ICU has no control, are ignored. In the second stage variation in operating efficiency is captured by a regression model. By focusing on the services provided by ICUs, the model alleviates the problem of measuring heterogeneous outputs, since all ICUs treat patients that are critically ill. Also, the analysis uses patient-level data rather than aggregate data, and incorporates quality measures, such as mortality probability. Despite the emphasis on quality variables, the author acknowledges that the analysis does not attempt to measure whether patients receive an appropriate amount of care; rather it presents mortality probability data showing severity of illness at admission. Also, the outcomes for these patients are determined by survival status at discharge. The measurement of technical inefficiency requires that ICUs minimise inputs given the amount of outputs produced. The paper acknowledges that measuring technical efficiency is adequate when comparing the performance of not-for-profit institutions, such as those found in the hospital sector (Puig-Junoy, 1998).

The choice of input set for Puig-Junoy's model is made up of both patient illness characteristics and clinical practice characteristics (Puig-Junoy, 1998). The seven inputs are: survival probability at admission, mortality risk level, weighted ICU days, non-ICU hospital days, available nurse days per patient, available physician days per patient, and technological availability. The output set contains: the number of days surviving in the hospital, and the surviving discharge status (Puig-Junoy, 1998, p 268-9). Many of the inputs used by the study, such as availability of nurse days, are determined exogenously and termed 'non-discretionary' because they cannot be modified when taking decisions to treat a patient. Therefore, it is not the use of these non-discretionary inputs that is being examined for efficiency. The efficiency estimates are determined 'given' these input levels, and calculated as 'short run efficiency'. The question being asked, is therefore:

> Given the level of labour (nurses and physicians) and technology available in the hospital, which is the efficiency level of clinical management in the treatment of a critically ill patient?
> (Puig-Junoy, 1998, p 268).

The answer to this question is somewhat obvious. In his conclusion the author notes that higher risk patients are managed less efficiently than lower risk patients. The existence of high risk, critically ill patients indicates a need for more resource use, with the intention being to prevent impending death. The author posits that devoting more resources to patients who eventually die is a form of inefficiency, since death could have been predicted to some degree.

> These results indicate that changes in clinical decisions may improve efficiency, given that the present resource allocation decisions do not seem to be closely related to the expected outcome. (Puig-Junoy, 1998, p 275).

The thrust of Puig-Junoy's study is to determine efficiency levels of clinical managers in ICUs based on the fact that financing ICUs accounts for 1 percent of GDP and 28 percent of hospital costs in the U.S. (Puig-Junoy, 1998, p 263). Corresponding figures are not provided for ICUs' health expenditure share in Catalonia (Spain), the subject of this study. This could be a significant factor if the financing and/or reimbursement methods in the two healthcare markets (US and Spain) differ.

Also, with the introduction of more radical surgery, made possible with better technology, the use of ICUs has been increasing (see Hayes, 1991). The result is that with technological change and an ageing population it is increasingly possible to use surgical interventions on patients who were not considered good candidates prior to the introduction of the latest technological innovation. This increases the reliance on ICUs to provide post-operative care. Puig-Junoy's analysis does not take this into account since it is based on resources used per patient. However, technological innovation clearly has an effect on total health expenditures, as discussed in section 2.1, which may be better explained using aggregate data.

The author outlines various limitations of using DEA, among which are omitted inputs and outputs, the assumption of no measurement error, and the assumption of no random fluctuations in the input-output set (Puig-Junoy, 1998, p 276). Another limitation of the DEA applied to healthcare, is to incorporate variables that attempt to measure quality, requiring value judgments and for which data is less reliable.

Street (2003) provides another application of stochastic frontier estimation to the hospital sector using cross-sectional data for English public hospitals. More specifically this paper compares the results obtained using corrected ordinary least squares (COLS) with results obtained using the SFE cost functions. There are two alternative results obtained for the SFE model since the model is run under two assumptions of the distribution of the inefficiency term, u_i. One of the SFE models assumes a half-normal distribution, and the other an exponential distribution. Furthermore, the author produces confidence intervals relating to each hospital's point estimate of relative efficiency. For the COLS model this shows the prediction error associated with uncertainty of parameter estimates. For the SFE models, the parameter estimates are taken as known. However the author imposes a distribution around the value of the inefficiency term conditional upon the total error term, ε_i. This provides critical values for the upper and lower bounds of u_i.

Findings from Street (2003) show quite different levels of efficiency for each technique. The COLS model suggests hospitals are on average 69 percent efficient, whilst the SFE model reports a mean efficiency of 90 percent (Street, 2003 p 904). Although both models agree on which hospital is the most efficient and which is the least, the rate of efficiency varies, as does the ranking of hospitals in between these two extremes. Quite rightly, Street posits that '…if the objective is to set hospital specific efficiency targets, it would be inadvisable to rely on a single specification of the error distribution' (Street, 2003, p 904). Clearly the use of cross-sectional data in these models suffers from the same problems outlined previously, namely that omitted variables appear as inefficiency and that periodic expenditures, which are not spread evenly over many years, would also appear as inefficiency for hospitals where they occur in the year of observation. Street lists a number of other reasons why the error distribution cannot be relied on, without attributing these to the use of cross-sectional data. Rather, the reasons given are based specifically on the hospital sector's unique characteristics such as society, regulators and hospital management having different notions of what they consider to be 'efficiency', the existence of excess capacity to enable emergency admissions, the inaccuracy of coding practices, and different accounting practices throughout the sector.

Craycraft (1999) identifies the necessity for nonprofit organisations to measure efficiency due to the growing reliance, in particular in the US hospital sector, for government to base reimbursement on efficiency. The author notes that hospitals are reimbursed a fixed rate to compensate for efficient treatment. This, combined with the rapid increase in hospital costs, '…has put pressure on hospitals to improve efficiency' (Craycraft, 1999, p 19). This author's main concern is to show how important accurate efficiency measurement is in order to identify inefficiencies. This process in turn provides the information necessary to realise cost savings through targeted inefficiency reduction.

Craycraft (1999) reviews various statistical techniques used in previous research to measure efficiency in hospitals and analyses the strengths and weaknesses of each method. The techniques compared are Ratio Analysis, Regression Analysis, and Frontier Analysis (DEA and SFE). The author notes that measuring efficiency is difficult, and inaccurate measures of efficiency may lead to poor decisions. If efficiency is improperly measured, it may lead to a misallocation of resources among and within hospitals. If hospitals are considered inefficient when they are truly efficient, resources may be inappropriately allocated away from these hospitals.

Craycraft's overview on the SFE technique sets out its limitations when using cross-sectional data and promotes the use of panel data to overcome these limitations. Specifically, the use of panel data overcomes the need to impose a functional form on the data. The author nevertheless states that caution should be exercised in basing policy decisions on the results from any of these techniques, but notes that the SFE compares favourably to other techniques.

> SFE allows better estimates of an individual hospital's efficiency measure and the sources of the inefficiency (whether technical or allocative). SFE also allows for the statistical and sampling errors common in empirical research. However, the lack of knowledge of the correct functional form to use or the effects of using an inappropriate functional form makes interpreting the results difficult.
> (Craycraft, 1999, p 25)

Clearly, the SFE with panel data is superior in measuring relative efficiency because it overcomes the main objection to using a cross-sectional SFE, which is to impose a functional form on the data. Also, panel data models require fewer assumptions because repeated observations on a number of decision-making units, such as hospitals, can take the place of strong distributional assumptions (Kumbhakar and Lovell, 2000).

2.3 General Applications of DEA and SFE

There are many general applications of frontier measurement in the literature but only some are outlined here. Schmidt and Sickles (1984) provide one of the first applications of the SFE using panel data. They explain that there are many advantages in panel data estimation, namely it is able to overcome the three serious difficulties inherent in SFE using cross-sectional data. These are:

- Increasing the sample size does not reduce the variance of the distribution of technical inefficiency.
- There is unknown robustness associated with the assumptions made about the distribution of noise and technical inefficiency. Statistical noise is assumed to have a normal distribution, and the distribution of technical inefficiency is assumed to be half-normal.
- It may be incorrect to assume that inefficiency is independent of the regressors since firms that are aware of their levels of inefficiency will change their input choices.

Reifschneider and Stevenson (1991) suggest a method for testing whether some portion of inefficiency departures from the frontier can be systematically explained. That is, they modify the basic frontier estimation approach so that it incorporates effects of conditions that may be associated with inefficiency. In this way their approach provides a framework for the analysis of the effects of potential determinates of inefficiency. The authors define a production frontier as one that specifies maximum outputs for given sets of inputs and existing production technologies. Similarly, a cost frontier defines minimum costs given output levels, input prices and the existing production technology. A cross-sectional model is specified for three separate time periods and incorporates firm-specific effects. The inefficiency model is developed to determine the reasons why inefficiency arises.

> Inefficient performance as measured by nonattainment of the production or cost frontier could reflect a conflict of objectives among participants…, alternative objectives…, shadow factor prices …, or simple ineptitude.
> (Reifschneider and Stevenson, 1991, p 719).

This model is applied to electricity generation data obtained for a sample of electric utilities.

Similarly Huang and Liu (1994) develop a cross-sectional SFE that estimates simultaneously the production frontier and the sources of efficiency in a single-stage model. That is, the model is a hybrid of the conventional stochastic frontier regression and a truncated regression inefficiency model. The authors identify a major drawback of the conventional models of frontier estimation to be that they fail to recognise that some inputs contribute more to inefficiency than others. That is, conventional models assume that an improvement in efficiency will shift the production function with no change to marginal rates of technical substitution.

> Firms may have acquired more information, knowledge, and experience with respect to one input productivity than another. Similarly, government policy or regulation on the use of inputs and production processes may either be constraining or beneficial to some, but not to all, inputs.
> (Huang and Liu, 1994, p 172).

According to this important development, the shift in the production frontier resulting from improved efficiency is non-neutral because it involves both a change in the productivity of inputs, and a change in the marginal rates of technical substitution. This is the rate at which one input can be substituted for another, for example capital for labour (Pindyck and Rubinfeld, 2005). One reason given for the difference in input utilisation is that, although firms may have the same production technology, older firms may be more efficient than younger firms due to increased experience in the production process. This model is applied to data of the Taiwan electronics industry (Huang and Liu, 1994).

Battese and Coelli (1995) note that Pitt and Lee (1981) and Kalirajan (1981) both adopt a two-stage approach to estimating technical inefficiency effects. They note that the first stage involves estimating the stochastic frontier production function and predicting the technical inefficiency effects under the assumption that these inefficiency effects are identically distributed. In the second stage the *predicted* technical inefficiency effects are regressed. This contradicts the assumption of identical distribution made in the first stage. Battese and Coelli (1995) proceed to acknowledge the work of Reifschneider and Stevenson (1991) and Huang and Liu (1994) (outlined above), among others, and develop the single-stage SFE further by introducing panel data. This model shows that, provided the inefficiency effects are stochastic, it can allow for time-varying inefficiency as well as the estimation of technical change in the stochastic frontier. This model is applied to the production of paddy farmers from an Indian village, with the null hypothesis being that the inefficiency effects are not stochastic and do not depend on the farmer-specific variables or time of observation.

2.4 Australian/Victorian Healthcare

Given that this thesis is concerned with Victoria's public hospitals' performance over four years of observation, it is not intended to thoroughly detail Australia's health system and its relative performance as a whole. Nevertheless, in order to put the Victorian experience into context, it is important to provide evidence of Australia's health sector and funding arrangements that were in place during this period. Donato and Scotton (1999), Duckett (1994), (1995) and (1999), Fetter (1991), Hall (1999), Lin and Duckett (1997), Magarry (1999) and Scotton and Owens (1990) provide evidence on the Australian and/or Victorian health care systems. Antioch et al. (1999), Southon (1994), Braithwaite and Hindle (1998), Phelan (1998), Walsh (1996), and Hanson (1998) all contribute to the debate over whether or not DRGs and casemix funding will benefit the Australian health market.

The Australian healthcare system is complex in the way it is funded and structured. Donato and Scotton (1999) provide an overview of health care arrangements in Australia, and the problems and issues in the system. The authors provide detail on the mixed private/public nature of funding and health provision. They also provide expenditure comparisons with OECD countries for the years 1975 to 1995 (Donato and Scotton, 1999, Table 2.2). These figures show that Australia's health expenditure trend (on average between 8 and 8.5 percent of GDP over this period) is consistent with most other OECD countries.

Donato and Scotton distinguish between expenditure on medical services (via Medicare) and expenditure on health care. They note that '[b]etween 1988/89 and 1994/95 expenditure on medical services grew at an average real rate of 5.4 per cent per annum, compared with 3.5 per cent for health care expenditure as a whole' (Donato and Scotton, 1999, p 28). The authors note that the reason this has occurred relates to the fact that medical services, provided by private practitioners (GPs and consultant physicians), are uncapped. Health expenditure, however, is subject to high-level negotiation between the States and Territories, and the Commonwealth, and is set out in Medicare Agreements/Australian Healthcare Agreements (see Section 3.3.3 below). Contributing to this disparity is that during the early 1990s in Australia there was an increase in the amount of medical services bulk-billed [see footnote 3]. The authors note that in 1992/93 65 per cent of medical services were bulk-billed, and by 1995/96 this figure rose to 71 per cent (Donato and Scotton, 1999, p 28).

Donato and Scotton (1999) acknowledge that many problems associated with Australia's health system are common among OECD countries. However, they also identify some problems that are unique to Australia. These problems, according to the authors, exist due to the peculiar nature of the institutional and structural characteristics of the Australian health system. Firstly is the problem of vertical fiscal imbalance, which is brought about by the dual funding of healthcare services by both the Commonwealth and the States. The fact that the Commonwealth cannot fund public hospitals directly (under the Constitution), and the States are restricted in how they can raise revenue within their boundaries, results in conditional government grants being distributed to States according to need. It is then the States' responsibility to administer their health programs subject to the level of funding received. Secondly the issue of declining private health cover has arisen due to the universality[3] of the Medicare system. The authors note that in 1983, the year prior to the introduction of Medicare, 63.7 per cent of the population was privately insured. One year later, following the introduction of Medicare, this figure fell to 50 per cent (Donato and Scotton, 1999, p 37). The authors posit that structural instability in financing originates from the fact that private cover is voluntary, and the universal system, funded through compulsory taxation, is available to all.

> In a private voluntary insurance system, substantial regulatory controls are required to mitigate the socially undesirable effects of competitive outcomes and market failures. When a universal public program is introduced, private voluntary insurance contracts to a

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[3] See Chapter 4 for a discussion of Medicare, universal insurance coverage and bulk-billing arrangements in Australia.

> supplementary role as the social welfare function is taken over by the public system.
> (Donato and Scotton, 1999, p 37).

For a historical description of the evolution of casemix funding in Victoria see Duckett (1994) and Duckett (1995). The author presents descriptive evidence on the reasons why casemix funding was designed (to improve overall efficiency and to reduce waiting lists) as well as providing a useful history of the development of diagnosis related groups in the US and Australia. Duckett (1995) discusses the effect of combining budget cuts with the introduction of casemix funding in Victoria. Budget cuts to healthcare were proposed by the newly elected Coalition Government as a solution to excessive debt in that State. The cuts were brought in over a three-year period (July 1992 to June 1995) and were given significant assistance through the Government's aggressive industrial stance. New industrial relations laws, together with once-off funds, provided hospitals with the ability to make forced redundancies and offer early retirement, thereby reducing staffing costs. This combination of circumstances resulted in a restructuring in hospitals '...changing the fixed/variable ratio – rather than simply cost reduction' (Duckett, 1995, p 118).

One of the arguments put forward against the implementation of casemix funding was aimed at the issue of teaching hospitals providing training and development, the additional costs for which would appear as greater inefficiency when compared with non-teaching hospitals. This problem was addressed by dividing hospital activities into four categories of outputs, namely inpatient services, outpatient services, training and development, and other specified programs (Duckett, 1995). This separation into sub-programs meant that each sub-program could be funded differently.

> Separate funding arrangements were developed for each of these sub-programs with the inpatient sub-program being funded on a casemix basis and the other sub-programs being funded on a mixture of casemix, historic and output bases.
> (Duckett, 1995, p 119).

Duckett (1995) details the process by which resource weights for inpatient services were developed in Victoria, namely by utilising patient level costing systems. The basic unit for payment became the weighted inlier equivalent separation (WIES).

This is a measure that firstly deals with exceptional cases or outliers, which are '...folded into the inlier payment to create an inlier equivalent separation...' (Duckett, 1995). In 1993/94 the calculation for an inlier equivalent separation was:

$$\text{Inlier equivalent separation} = \left(1 + \frac{\text{Total days above outlier trim point}}{\text{Average length of stay for the DRG}}\right)$$

Thus, cases with zero days above the outlier trim point would result in an IES equal to 1. The denominator in the IES calculation was altered in 1994/95 to '2 x Average length of stay for the DRG'. In this way the calculation better deals with the situation where costs in the first few days of admission are higher than later days, which is particularly relevant for long stay cases.

$$\text{Inlier equivalent separation} = \left(1 + \frac{\text{Total days above outlier trim point}}{2 \times \text{Average length of stay for the DRG}}\right)$$

The IES is then multiplied by the resource weight for that DRG to arrive at the Weighted Inlier Equivalent Separation (WIES) (Duckett, 1995). Once this figure was calculated in Victoria, it was possible for payment to be made with both a fixed and variable component. The total 'benchmark efficiency price' was set at $1650 per private WIES. The fixed component was calculated to be $850 per WIES and the variable payment $800 per WIES (Duckett, 1995). The variable component was only guaranteed up to a hospital's activity level (separations) in 1992/93 (the base year). The fixed component was also calculated using hospital activity in a base year (the 1992 calendar year). Both of these components were set to reflect the costs of an 'efficient' hospital, against which all hospitals would be measured.

> In particular, the variable payment needed to be set to reflect marginal costs in an efficient hospital but not to provide too great an incentive to expand activity.
> (Duckett, 1995, p 120).

For the variable component, activity above the base year activity level was reimbursed from an 'additional throughput pool'.

> In 1993/1994, sufficient funds were set aside to pay for a 7% increase in patients treated in the first year of casemix funding.
> (Duckett, 1995, p 121).

The additional throughput pool was a political tool to provide the incentive for hospitals to increase throughput. The total payments from the pool were capped, in that the amount available in the pool was fixed, and the price per additional patient treated was allowed to fluctuate. This was necessary because Government set the total amount available in the pool, and the increased throughput was determined by hospital activity on a quarterly basis. Thus, changing the price for additional patients treated ensured that the pool did not expire. There was also an incentive in place to reduce waiting lists by making access to the additional throughput pool conditional upon meeting certain targets with regard to category 1 and 2 patients that were on the waiting list (Duckett, 1995).

Duckett (1995) also outlines the treatment of teaching hospitals under Victorian casemix funding. The author notes that, despite standardisation of cases using DRGs, teaching hospitals still exhibited higher costs than their non-teaching counterparts due to the nature of education and research conducted by them. These extra costs and 'products' were addressed through additional funding. This "...separate teaching product [was] to be funded by a 'Training and Development Grant'" (Duckett, 1995, p 125).

The issue of quality maintenance in hospitals was also of concern to those responsible for implementing casemix funding in Victoria. Many considered that the move to casemix funding in pursuit of improved efficiency would endanger health outcomes. This concern led to the requirement that all hospitals produce a quality assurance plan annually (Duckett, 1995). Hospitals were also encouraged to participate in the Australian Council of Healthcare Standards accreditation process. Accreditation by hospitals to this organisation was rewarded with an annual specified grant. Data also began to be collected from hospitals on unplanned re-admission rates as this was considered to be '...the best indicator of potential quality problems' (Duckett, 1995, p 127). Furthermore, consumer experience of hospitals was measured with a consumer satisfaction survey that provided data on patients' perception of care received (Duckett, 1995).

Duckett (1995) concludes by elaborating on the perverse incentives which are inherent in casemix funding, and which may work to counter ethical practice. These are identified as increased unnecessary admissions, hospitals providing only activities for which they are paid, the neglect of altruism in health provision, and ethical/medical risks of medical practitioners' early discharge decisions.

Duckett (1998) compares inpatient funding arrangements across the five States that have either already implemented casemix funding or are intending to in the near future. The author concludes by stating that differences between States should not preclude the possibility of learning across State boundaries, in order to achieve best practice in this area.

Duckett (1999) deals with hospitals in Australia; their capacity and utilisation, funding arrangements, and how hospital services are categorised. The author provides an overall picture of the Australian healthcare landscape, including statistics showing State and Territory comparisons for 1995/96 of the number of hospitals, beds, beds per 1000 population and beds per hospital for both the public and private sectors (Duckett, 1999, p 94, Table 5.1[4]). Further data are provided on the provision and use of acute hospitals in Australia between 1985/86 and 1993/94. These data show a declining trend in the number of public acute hospital beds per 1000 population (22 per cent) and private acute beds (7.7 per cent) over the period. Separate data are provided for metropolitan and non-metropolitan regions. In rural areas the decline in public acute hospital beds has been more marked at almost 30 per cent. The author attributes this decline to '...specific government policies to reduce bed provision...' (Duckett, 1999, p 96). Conversely, the rural trend for private acute beds per 1000 population shows an increase of over 42 per cent over the period. The author attributes this trend partly to a reduction in population in those areas, and partly to new private hospitals being constructed in rural areas (Duckett, 1999).

Duckett (1999) also identifies productivity changes with the use of data on admissions, average length of stay (LOS) and occupancy data. For both public and private sectors over the period there is an increase of admissions per 1000 population of 21.6 percent and 27 per cent respectively. These data, coupled with reduced LOS (by 30 and 25 percent) and increased occupancy rates (by 11 and 8 percent), show significant productivity improvements overall. The author notes that LOS reduction is due to the increase in day-only patients and reduction in stays of long duration. He attributes this trend to the effect of improvements in medical technology over the

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[4] Table 5.1 is reproduced in Chapter 4 (Table 4.5) of this thesis.

period (Duckett, 1999). The author continues with an outline of the historical development of hospital funding in Australia, the development of the Medicare Agreements, and the changing share of hospital expenditure by State and Commonwealth sources.

Duckett (1999) notes that casemix funding places incentives on hospitals to provide appropriate care in an efficient manner. This is because casemix funding is paid to hospitals per patient treated and as a reimbursement. Although the author acknowledges that hospitals cannot determine how many people present themselves, with varying types of illness, they do have control over the length of stay, the number of tests ordered, and the costs associated with hospital stays. The incentive for hospitals to be more efficient with their allocated funds lies in the way that the '...funder or purchaser assumes the risk for cost variations caused by variations in the number and type of patient treated, by setting differential prices for different types of patients and allowing budgets to vary with volume' (Duckett, 1999, p 107). The prices noted here are determined by grouping diagnoses by their characteristics. These Diagnosis-related Groups (DRGs) provide a standard for differences in the case-mix of hospitals. Duckett (1999) sets out the development and adoption of DRGs by Australian States up to 1999. Broadly, casemix funding relies on DRG cost weights as a standard payment for a particular DRG. Cases either above or below this 'normal case' (outliers) attract higher or lower payments. These developments and increased reliance on economic incentives are proposed to direct efficiency and effectiveness of the hospital system into the new century. Duckett (1999) also stresses the need for improvements to be made in the measurement of efficiency and, accordingly, the changing nature of hospital services/products and how these are defined.

The literature on hospitals and government expenditure shows that there is some relationship between the type of government funding and overall expenditure. Antioch et al. (1999) compare Victoria and New South Wales using the benchmark funding rates for WIES. They use data on per capita health spending in different States, and per capita hospital spending, after adjusting for dispersion and scale. From this analysis, Antioch et al. (1999) show the change in per capita public hospital costs in Victoria from 1991-92 to 1995-96.

> 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.
> (Antioch et al., 1999, p 135).

Antioch et al. (1999) produce multiple regressions that identify independent variables impacting on Victoria's per capita expenditure (adjusted by the CPI) on recognised public hospitals. These variables include Victorian Gross State Product per capita, the unemployment rate in Victoria, the proportion of public beds to total public and private beds in Victoria, a dummy variable for the introduction of casemix funding and funding cuts, and the ratio of non-same-day separations to same-day separations in Victorian public hospitals. The authors take results from the OECD's 1993 cross-country econometric work that explores factors affecting health spending, and use them to estimate their model. The OECD results indicate that countries that pay physicians by capitation, countries where patients pay the provider and then seek reimbursement and countries with more doctors per capita all have lower overall expenditure. Among the key findings for their research Antioch et al. (1999) note that, as expected, funding cuts and the introduction of casemix funding led to falls in expenditure on recognised public hospitals. They stress, however, that the introduction of casemix funding did not cause funding cuts.

> 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.
> (Antioch et al., 1999, p 148).

Phelan (1998) provides an explanation as to why DRG-based funding was necessarily implemented in Victoria. He notes the overall cost savings generated since its implementation and provides both the benefits and possible problems associated with DRG-based funding. The author acknowledges that budget cuts were necessary in Victoria, and that DRGs assisted the process by making budget cuts more equitable across hospitals. Also, DRG-based funding improved work practices, and altered the management mix in hospitals.

> Many hospitals realised that, if they were to manage the changes successfully, they had to involve clinicians in senior management, as their decisions are responsible for about 80% of healthcare costs.
> (Phelan, 1998, p 560).

Phelan (1998) notes other successes in Victoria stemming from the introduction of DRG-based funding. Among these were less (expensive) investigations, better managed length of stay, and the deliberate move to day-only surgery. Also, discharges were no longer delayed pending the twice-weekly consultant ward round (Phelan, 1998).

In terms of deficiencies of the way DRGs were applied in Australia, Phelan (1998) notes that the version of DRGs adopted by the Commonwealth was out of date and, therefore, resisted by clinicians. Also, with the exception of Victoria, there were insufficient incentives for hospitals to collect patient-level data for costing purposes. The issue of heterogeneity of cases also impacts on the effectiveness of DRG-based funding. Phelan (1998) posits that DRGs should only be used to fund hospitals with similar patient mix. He also notes that small hospitals are disadvantaged because they '...do not have sufficient throughput to balance out variability' (Phelan, 1998, p 560).

Hanson (1998) provides evidence on the limitations to using Australian National DRGs (AN-DRGs). These limitations include inadequate measures of severity of illness being incorporated into DRGs, and the poor quality of patient data available to form the groups. The author also suggests that DRG-based funding was developed too quickly and resulted in perverse incentives as healthcare providers struggle for survival.

> A DRG-based payment system is meant to be about allocative efficiency, and not about increased throughput and profiteering. In an underfunded healthcare environment it should have come as no surprise that perverse incentives would be difficult to control, and that the focus would not be on quality and outcomes, but rather on the survival of healthcare services.
> (Hanson, 1998, p 561).

This point regarding the reason why DRG-based funding was implemented is central to the controversy over whether the new funding arrangements are viewed as beneficial or not. Clearly, the issue of whether the intention is to improve allocative efficiency or technical efficiency is important in whether or not the funding method is accepted by clinicians and commentators. Those authors who are not entirely against the use of casemix funding based on DRGs[5] present arguments for casemix funding based on improvements in *productivity*. Productivity is defined as increased output for a given input, and forms part of *technical* efficiency. Those authors who present arguments against the use of a DRG-based payment system do so with concerns of reduced quality and reduced services provided by hospitals. These are issues of *allocative* efficiency because they deal with the combination of products/services being produced due to the alteration in the way that resources are allocated in the production process. The new funding arrangements alter the incentives to produce and, therefore, may impact negatively on allocative efficiency. The point of contention is whether these negative effects (by not producing what society wants) on allocative efficiency counteract the positive impact (improved productivity) that casemix funding has on technical efficiency.

Another contrary view to using DRGs in the casemix funding process is provided by Braithwaite (1994) and Braithwaite and Hindle (1998). The authors argue that DRGs take a simplistic view of variations in patients' needs (including severity of illness and comorbidity). They state that DRGs fail to respond with sufficient speed to developments in technology and science and are out of date by the time they are used. They also argue that there are data problems involved in the clinical process such as coding errors, misdiagnoses and medical uncertainties. The use of DRGs, however, suggests that classifying patients can be scientific and precise. Braithwaite and Hindle (1998), although generally in agreement, contradict Hanson (1998) above, to the extent that they consider that DRG funding attempts to promote *technical* efficiency, whereas Hanson (1998) (see above) posits that DRG-based payment systems are about *allocative* efficiency.

> DRG funding attempts to promote technical efficiency in only one part of the healthcare sector – the acute care of inpatients.
> (Braithwaite and Hindle, 1998, p 558).

Braithwaite and Hindle (1998) also point to some ethical considerations in applying economics to healthcare. The authors note that neoclassical economists espouse that productivity and efficiency are driven by incentives, whereas healthcare workers are motivated 'from within' to provide quality care to patients (Braithwaite and Hindle,

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[5] See for example Walsh (1996), Phelan (1998) and Duckett (1999).

1998, p 559). Whilst it is true that paid nursing staff and allied workers do exceptional work with regard to improving health outcomes of patients, the issue of efficiency deals with the way that resources are managed. That is, the focus of DRG-based funding is on managerial decision-making, and not individual staff job descriptions. Ethical arguments against DRG-based payments are emotionally charged and offer populist viewpoints that do not necessarily aid in the advancement of finding better ways to apply increasingly scarce resources to the growing market for healthcare.

Walsh (1996) contends that casemix funding is a major advance over the historical budgeting procedure that existed in Victoria prior to July, 1993. He also argues that under casemix funding there is a focus on efficiency and much greater accountability for the use of funds and hospital management performance. Among the achievements under casemix funding, the author notes an increase in productivity in Victorian hospitals with '...15% more work with 10% less money since 1992-93' (Walsh, 1996, p 133). The list of achievements includes a 30% increase in day-only cases (spanning over 2 years), increased throughput, declining waiting lists, and improved emergency access. Among the disadvantages of casemix funding, the author notes that '[t]here is still too much emphasis on inpatients and too much emphasis on throughput' (Walsh, 1996, p 133). The issue of 'averaging' is also considered a disadvantage since hospitals that specialise have only a limited number of patient categories and many of these may require intensive care treatment, which is costly and requires longer stays.

Southon (1994) offers a perspective on Victoria's health reforms in light of long-term effects. He argues that hospitals do not operate like traditional markets since a third party is involved in payment for patient services, and outlines the existence of perverse incentives in health markets[6]. Southon (1994) notes that the move to a 'managed market' for healthcare in Victoria may significantly increase administrative costs rather than reduce them. The author argues that costs may rise due to increased workloads associated with maintaining the fee schedule, responding to hospital appeals for special treatment, and ongoing alteration of hospital strategies

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[6] For a discussion of market failure and asymmetric information in health markets, see Evans (1984) (outlined in Chapter 4 of this thesis) and Donato and Scotton (1999) in this chapter.

to ensure that they remain competitive (Southon, 1994). Furthermore, the author identifies institutional effects of hospitals that, together with change in management style required under reforms, could impact detrimentally on hospital performance in the longer term (Southon, 1994). In conclusion, the author states that the Victorian experiment is a brave initiative that has been met with some early successes. He also states that inherent management costs in health reforms could detract from service provision, degrading long-term clinical capabilities.

Lin and Duckett (1997) provide a summary of the health reform process in Victoria in terms of the introduction of casemix funding. The authors express concerns over the effect of DRGs on quality outcomes where hospital activity could be misinterpreted as efficiency without regard to outcomes. Further descriptions of the Victorian health reform agenda can be found in Fox (1996), and Tonti-Fillippini (1996).

In 1997 the Steering Committee for the Review of Commonwealth/State Service Provision published a report with various applications of the DEA technique to government services. One of the case studies in this report details the results of an application of DEA to Victorian hospitals for a single year, 1994-95. Since only a single year’s data is collected, the analysis reports on relative technical efficiency of hospitals, rather than efficiency scores over time (Steering Committee, 1997).

2.5 Hospital Mergers

Given that Victorian hospitals experienced considerable merger activity during the period under observation, it is relevant to review literature on hospital mergers. Lynk (1995) measures efficiencies in hospitals following mergers, and finds that significant real efficiencies are created through mergers. This arises because mergers between hospitals result in increased specialisation, where particular clinical services are consolidated. For example, one hospital campus would contain all paediatrics, and another all cardiac surgery. Lynk also ascribes efficiencies arising from staffing cost reductions due to less variability of daily patient census following mergers. This paper is challenged by Keeler et al. (1999) and Dranove and Ludwick (1999).

Keeler et al. (1999) find that higher hospital concentration leads to higher prices. This is corroborated by Dranove and Ludwick (1999) who find that mergers of non-profit hospitals result in higher prices. The authors propose that they are able to correct for the problems in Lynk's analysis associated with the endogeneity of market share, the need to control for severity/quality of illness and the need to exclude low concentration markets. With regard to severity and quality, the authors contend that these are inversely related to concentration. Dranove and Ludwick (1999) also quote evidence that suggests that scale economies enable hospitals in more competitive markets to offer more 'hi-tech' services that may enhance quality of care. Also, they note that the most up-to-date technology attracts better skilled physicians, leading to improved outcomes.

In response to this challenge, Lynk and Neumann (1999) present arguments that defend the findings in Lynk (1995). The authors suggest that Dranove and Ludwick (1999) and Keeler et al. (1999) focus their attention on an empirical finding that was not central to the 1995 paper. They also contend that these recent findings confirm Lynk's earlier work and that hospital pricing data cited by Dranove and Ludwick and Keeler et al. actually confirms that the non-profit hospital pricing tendencies in Michigan are consistent with allowing a hospital merger to take place. They also note that their own evidence is consistent with the other authors in that they find that non-profit and for-profit hospitals behave differently in terms of the characteristics of hospital pricing.

Frech and Danger (1998) deal with exclusive contracts between hospitals and physicians, and explore antitrust issues in rural markets. The article analyses the economic motivation for hospital-physician exclusive contracts and assesses under what circumstances such contracts may be anticompetitive in intent and effect. They conclude that both hospital and physician market power is declining as managed care plans make the environment more competitive. However, they also note that there are developments, such as large provider networks, that could decrease competition.

2.6 Discussion

This review of the literature highlights the key issues that are significant in the development of this thesis. Whether hospitals manage their inputs (resources) efficiently relies to a great extent on policymakers putting in place the correct incentives to bring about desired behaviour. Policymakers have many issues to consider when determining the structure of incentives, since the operations of public hospitals are complex and exhibit relationships and processes that do not exist in the competitive market. The cost-increasing effect of new technology, for example, is an area requiring particular attention. It is widely recognised that innovations stemming from research and development are a desirable outcome in the pursuit of improving living standards generally. In medicine, technological advances improve medical capabilities, thereby reducing patient recovery time, and/or improving procedural success rates. These benefits accrue directly to patients and also indirectly to the wider community when consideration is made of reducing the amount of work time lost to hospitalisation and/or illness. The increased costs, however, accrue to the healthcare sector and are subject to the funding arrangements in place.

Casemix funding arrangements were implemented in Victoria in order to put an end to historical budgets, reduce costs, and to put in place incentives to improve technical efficiency in healthcare. One point that arises in the literature is predicated upon whether DRG weights used in casemix funding should be related to the performance of procedures (retrospective), or whether they should be related to actual diagnoses (prospective). Payments based on retrospective DRGs are associated with increased reimbursement since these DRGs are treatment-related and, depending on severity of illness, carry relatively higher weights. More intensive treatment is further enabled by the existence and use of new technology which, in turn, provides patients with surgical options that increase treatment costs. DRGs that capture actual diagnoses, and that are prospective, are a better tool for ensuring that resources will be used efficiently in treatment. Uncertainty arises, however, due to the fact that initial clinical diagnoses are not always correct and, concomitantly, retrospective DRGs better reflect the imprecise nature of clinical practice decisions.

Frontier methods have previously been applied to hospitals and healthcare providers elsewhere. These methods are all aimed at identifying inefficiency and the reasons why it exists in healthcare. The findings show that inefficiency and hospital profitability are inversely related, whereas excess capacity, higher costs, and inefficiency are positively related. Results that purport to measure quality of care are proffered cautiously due to the subjective nature of the data being considered. The use of frontier methods in comparing hospital efficiency is defended, however, on the grounds that both the DEA and SFE techniques provide ‘signal devices’ that alert policymakers to possible differences in the way that individual hospitals manage their funding. A great deal of debate in the literature centres on the issue of whether to use DEA or SFE, with either cross-sectional or panel data. On balance it would appear from the literature that the strongest arguments put forward for comparing hospitals for efficiency favour the use of the SFE using panel data.

In order to develop an understanding of Victoria’s experience with casemix funding arrangements, the evidence is reviewed for the Australian healthcare system. It is clear from this that Australia is unique in the way that healthcare is funded and structured. Vertical fiscal imbalance (spawned by the Australian Constitution) provides the backdrop for understanding the separation of health funding by the Commonwealth and States. Similarly, the parallel existence of public and private health systems, and the incentives that direct consumer choice between the two are issues that impact directly on total public health expenditure. This literature feeds into the issue of policymakers determining where and how limited funds are allocated such that the growing demand for health services is adequately met without wasting resources. Casemix funding is a tool, therefore, designed to enable policymakers to execute these objectives. For all the objections raised to casemix funding being implemented, it is apparent that on balance the Victorian experience has successfully aided our ability to at least influence the allocation of scarce resources, even if not to improve productivity. This thesis will show that it was, in fact, hospital merger activity following Victoria’s move to casemix funding that secured the efficiency gains that Victorian policymakers were seeking, and not improved efficiencies within individual hospitals.

Chapter 3

Background to the Methods

3.1 Overview

There are three techniques used in this thesis that, collectively, contribute to understanding the effect of health reforms and casemix funding in Victoria. The first is survivor analysis, which identifies economies of scale and optimum organisational size. The second is data envelopment analysis, which compares efficiency of public hospitals by producing a deterministic frontier. The third is the stochastic frontier estimation technique, which also compares efficiency of public hospitals, but with a frontier that contains a stochastic error term. These three techniques are discussed individually to clarify and expose their underlying assumptions, advantages and limitations.

3.2 Survivor Analysis

The survivor analysis technique was developed to measure and reveal the optimum size of organisations, where ‘optimum’ refers to efficient size given the environment within which firms operate (Stigler, 1958). An organisation’s scale is therefore closely aligned with its use of resources, leading to either economies or diseconomies of scale, depending on how well those resources are combined. Stigler’s work that develops this technique provides some useful insights into the theory of economies of scale. This theory forms the foundations upon which the survivor technique is built.

> The theory of the economies of scale is the theory of the relationship between the scale of use of a properly chosen combination of all productive services and the rate of output of the enterprise.
> (Stigler, 1958, p 54).

Although the technique relies upon the existence of the competitive market mechanism to drive efficiency, it can be used to examine efficiency in hospitals, for example, where public policy has altered such that funding becomes conditional upon hospitals attaining improved efficiency in production. In the case of California, public policy changes in the 1980s resulted in a deregulated private and public health insurance industry, presenting an opportunity to apply the survivor technique (Frech and Mobley, 1995). Similarly, this thesis shows that health reforms in Victoria, which included the switch to casemix funding, had an analogous effect in that the new policy mimics the competitive market by requiring public hospitals to improve efficiency levels (Duckett, 1994).

Stigler posits that the survivor technique is able to determine efficient organisational size due to its underlying assumption, which is that '...competition of different sizes of firms sifts out the more efficient enterprises' (Stigler, 1958, p 55). This assumption was first made by Mill (1909) who recognises that firms in the same business, that are able to undersell their competitors, will prevail since they are more profitable.

The basic technique works by classifying firms in an industry by size and calculating market share for each class over time. As the market share of a particular class falls over time, then that group is considered relatively inefficient. The quicker the reduction in market share, then the more inefficient is the particular sized group (Stigler, 1958). Stigler also notes that firms that survive do so because they are better able to cope with 'strained labor relations, rapid innovation, government regulation, unstable foreign markets, and what not' (Stigler, 1958, p 56); environmental factors that all firms in the industry are subjected to at the time. Frech and Mobley (1995), in their application of this technique to California short-term general hospitals, note that grouping hospitals according to number of beds, rather than bed days, best represents size. This obviates the problem of confusing the results obtained from medium sized low-occupancy hospitals with small sized high-occupancy hospitals.

Stigler (1958) acknowledges that the survivor technique does not attempt to measure the socially optimum efficient size; which may be altogether different from the survivor optimum. The social optimum would take into account misuse of market power arising from monopoly power and discriminatory practices in labour relations. Stigler notes that the social optimum is '...fundamentally an ethical concept...' (Stigler, 1958, p 56). This point is also pertinent in measuring optimum size of hospitals. Clearly, the existence of either economies or diseconomies of scale is not necessarily analogous to the social optimum size of hospitals. Rather, the survivor technique provides *descriptive* estimates of optimal size, which helps to identify the surviving size ranges (Shepherd, 1967).

Shepherd (1967, p 114) provides some advantages and limitations of survivor analysis. Three advantages are that the technique:

1. Finesses the problem of the capitalization of rents into costs;
2. Deals directly with plant size; and,
3. Reflects trends and adaptive processes in industries, rather than dealing only with single periods.

The first advantage deals with the process that drives average costs towards equality. Shepherd notes that this problem has been long recognised and has ‘seriously undermined the cross-section and time-series cost studies’ (Shepherd, 1967 p 114). The second point means that there are no problems in having to define the unit of output to allocate joint costs correctly. The survivor estimates deal directly with the plant size. Thirdly, Shepherd notes that this technique ‘...embraces dynamic elements which could tie its results in with an analysis of industrial behaviour which tries to go beyond traditional static-equilibrium assumptions’ (Shepherd, 1967, p 114). Despite these advantages, Shepherd notes that the technique cannot be used on its own, rather it may generate ‘...preliminary or supplementary indications of certain ranges in industry cost functions’ (Shepherd, 1967 p 116). The reason for caution is borne out by the technique’s limitations, some of which, identified by Shepherd, are noted below.

According to Shepherd the first limitation of the technique is the fact that its estimates of optimality are descriptive, not normative, and do not provide information on what the level of efficiency should be. The estimates of optimality tell us ‘...what *is*, not necessarily what is *optimum* or *efficient* in terms of net social costs (Shepherd, 1967, p 115)[7]. Furthermore, Shepherd states that this limitation is most severe in those industries where normative estimates are warranted, such as industries with market imperfections; industries that require public policy. Also, in terms of the scale economies that result from the technique, Shepherd notes that the

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[7] Stigler (1958) acknowledges this limitation, as noted above.

results show the borders of a range, not the more indicative *degree* of scale economies. He goes on to describe how the survivor technique, in identifying a range of ‘optimal size’, mistakenly purports to equate this range with one of ‘constant costs’. However, firms within an optimal size range may exhibit increased revenues over the period, not necessarily lower costs. Since firms within a size range still vary in size, they may also therefore vary in costs (Shepherd, 1967). Another limitation is that the technique treats single-plant and multi-plant firms alike, without regard to the fact that large firms are more likely to have relatively larger plant than small firms. Similarly, the years chosen for analysis will affect the results if, for example, a firm *temporarily* reduces output during the period under investigation.

Frech and Mobley (1995) note that an advantage of survivor analysis is that it includes ‘...factor which often cannot be measured and used in statistical studies of cost or production’ (Frech and Mobley, 1995, p 288). This is because as market shares change over time, it is an indication of a firm’s unique situation; i.e., its management strategy and output quality. In order to overcome the limitations of the basic survivor technique outlined by Shepherd (1967), Frech and Mobley also extend the technique to a second analysis by utilising the multivariate model originally proposed by Keeler (1989). Frech and Mobley’s second analysis estimates a binary model (the firm grew or did not grow) but stresses a continuous growth version. This multivariate model controls for other factors such as chain affiliation, adverse selection and local market conditions on survivorship, in addition to efficiency, all of which enhance growth of firms. They find, nevertheless, that the results from this second model are similar to Stigler’s basic univariate model for scale economies.

> The multivariate approach is intrinsically interesting but it is not important for estimating scale economies in this data...These equations are similar in spirit to the basic Stigler-type survivor analysis presented above. The results are very close to those of the three multivariate equations. Focusing on the unweighted versions for simplicity, the predicted scale economies are identical.
> (Frech and Mobley, 1995, p 292).

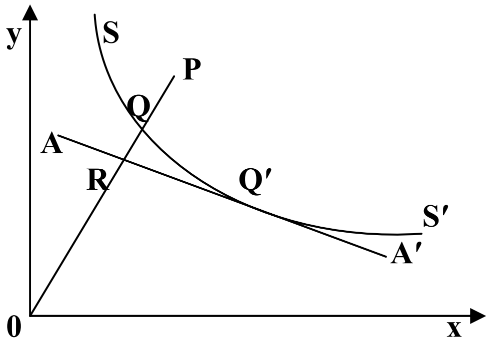
These results suggest that the basic univariate model is an appropriate and useful tool in determining hospital scale economies, especially when the results are viewed in conjunction with results using other methods, such as frontier estimation techniques.

3.3 Data Envelopment Analysis

Measures of efficiency provide economic policymakers with the tools necessary to compare firms or industries in relation to their use of inputs in the production of outputs. Farrell (1957) identifies the problems that arise when efficiency is measured using a theoretical function specified by engineers, and develops an empirical function based on best results obtained in practice. The theoretical function, although useful when looking at a single production process, fails to accommodate the complexities known to exist in a single manufacturing firm or in industries. One such complexity is the use of indirect labour, which cannot be easily estimated theoretically. 'Thus, the more complex the process, the less accurate is the theoretical function likely to be' (Farrell, 1957, p 255). The author argues that a benchmark for comparing efficiency should be realistic (i.e., best results obtained in practice) to avoid 'unfortunate psychological effects' that may arise when performances are measured against some unattainable ideal.

In a simple case, the efficiency model proposed by Farrell illustrates a measure of the technical efficiency of a firm using two factors of production (inputs) to produce a single output under conditions of constant returns to scale. In order to explain the workings of the model, Farrell assumes that the efficient production frontier is known[8]. The author uses a production isoquant diagram which illustrates the technical and allocative efficiency measures. It is duplicated in Fig. 3.1.

Figure 3.1 –Technical and Allocative Efficiency Measures



Source: Farrell (1957) p 254.

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[8] The efficient frontier is of course estimated from the data using the linear programming technique, data envelopment analysis, later developed by Charnes, Cooper and Rhodes (1978).

From Fig. 3.1 it is possible to identify technical efficiency, allocative efficiency and economic efficiency[9]. Point P in Fig. 3.1 is the actual level of input combination of a firm, and the isoquant SS′ is the assumed efficient production frontier for the industry. The assumptions made for the production isoquant are that it is convex to the origin and secondly, that the isoquant is nowhere positive. Convexity ensures that if two points are attainable, then so is a weighted average of the two. The non-positive requirement must hold otherwise '…increased applications of both factors would result in reduced output' (Farrell, 1957, p 256). The firm operating at point P is inefficient because, according to the frontier, it could reduce the quantities of inputs x and y and still produce the same level of output on the isoquant at point Q. Thus, technical efficiency of firm P is given as the ratio 0Q/0P.

Figure 3.1 also shows an input price ratio (also assumed) of AA′. Given this tangent to the isoquant, it is possible to identify allocative efficiency at point Q′. Thus, even though any point along the isoquant is considered technically efficient, there is only one point on the isoquant that is considered to be the *optimal* combination of both inputs to produce the efficient level of output. This optimal point is determined by the ratio 0R/0Q, which shows by how much factor costs will further need to be reduced in order for the firm to have allocative efficiency. Thus, total economic efficiency is the product of technical efficiency and allocative efficiency:

$$EE = (0Q/0P) \times (0R/0Q) = 0R/0P$$

It should be noted that when Q′ is achieved by altering the combination of inputs, it may be the case that technical efficiency will also change, thus altering the position and/or shape of the production isoquant[10]. This qualification is acknowledged by Farrell when he notes that, regardless of this, EE is the best measure of total efficiency available (Farrell, 1957). Notwithstanding Farrell's qualification, it is intended to focus solely on the measurement of technical efficiency in this thesis.

The production isoquant can be better understood if illustrated as a piecewise linear convex isoquant. At the very foundation of constructing a production isoquant is the

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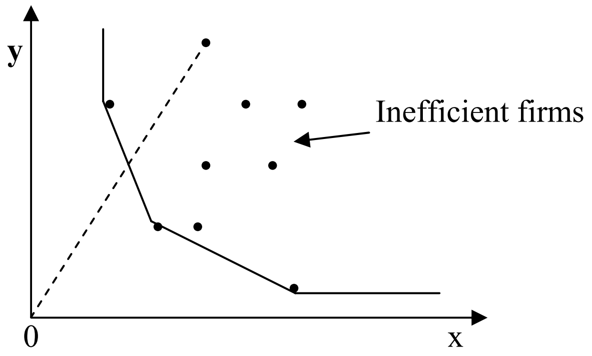
[9] These are noted by Farrell as technical efficiency, price efficiency and overall efficiency respectively.

[10] The main reason that DEA is used in this thesis to measure technical efficiency, and not total efficiency, of Victorian hospitals is due to the uncertainty surrounding the shape of the production isoquant following a change in input combination.

assumption of convexity for which two observed points on the isoquant share a weighted average of all points between them. Thus a straight line between two observed points (actual firms) contains a hypothetical firm that produces the same level of output. Fig. 3.2 illustrates the piecewise linear convex isoquant with many firms using inputs x and y in differing combinations in the production process. Actual firms that lie on the isoquant determine its shape, with hypothetical firms (unmarked) lying on the straight line portion in between observed firms.

Figure 3.2 – Piecewise Linear Convex Isoquant



From Fig. 3.2 the dashed line from the origin represents the input proportions of x and y of an inefficient firm. Where the dashed line passes through the straight line portion of the isoquant represents the hypothetical firm's production, ie a weighted average of two existing 'efficient' firms[11], but using the same input proportions (x and y) of the inefficient firm, most notably in smaller quantities. The formation of a hypothetical firm is noted by Farrell as being the essence of the method, and not the use of an isoquant diagram. In the case of multiple inputs and outputs the diagram is abandoned, however the principle of forming a hypothetical firm remains.

Farrell (1957) also provides the mathematical generalized case of multiple inputs and outputs to show how to calculate inefficient firms' distance from the assumed isoquant. Since this is a problem of minimising inputs, the first consideration is to find the efficient points (firms) that establish the best results obtained in practice. Therefore a pair of points, and the straight line between them, must satisfy two conditions:

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[11] The two points on the isoquant are actual firms that are labelled in the literature as 'peers' of the inefficient firm.

(i) that the slope of the line is not positive; and,
(ii) that no observed point lies between it and the origin (Farrell, 1957, p 256).

With these conditions satisfied, the two chosen points will provide the best results obtained because they represent firms in an industry that are able to use the relatively minimum amount of inputs in the production process. These firms, along with others that satisfy the above conditions, form an efficiency benchmark for the industry under consideration. This discussion relates only to the estimation of technical efficiency, and Farrell observes that this is a relatively uncomplicated measure of efficiency when compared to the difficulties associated with the measurement of allocative efficiency. For example, there is the assumption that firms face identical prices in the measurement of allocative efficiency[12], but this is not a consideration for measuring technical efficiency. Despite this relative advantage, Farrell also makes certain qualifications when interpreting technical efficiency.

Among the limitations of the measurement of relative technical efficiency is that any increase in the number of firms under consideration may reduce technical efficiency of a given firm relative to other firms, but never increase its relative technical efficiency. This is because as the size of the sample increases, the probability increases that additional firms will produce in relatively more efficient ways. Farrell illustrates this by observing that '…a firm may be highly efficient by British standards, but not by world standards' (Farrell, 1957, p 260). Secondly, inputs are not always homogeneous and there may be significant quality differences, such as the quality of skilled labour. This point highlights the difficulty in separating managerial decision-making from the differences in quality of factors of production in the efficiency estimate. Farrell notes that '…it is never possible to decide precisely…how far the laziness and intractability of a particular firm's labour force is ingrained and how far the product of bad management' (Farrell, 1957, p 260). Furthermore, the omission of an input that is utilised by one firm more than others will result in that firm having a higher technical efficiency estimate. Despite these limitations, Farrell notes that technical efficiency is a satisfactory way of measuring efficiency.

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[12] Refer to Fig. 3.1 for an illustration of identical prices using price line AA′.

Technical efficiency is, therefore, a measure that provides information to the policymaker on whether to alter management practices, without the factor price problems associated with allocative efficiency. Farrell notes that the allocative efficiency measure is dubious due to the fact that it is sensitive to the introduction of new observations. Problems arise when new observations affect the slope of the price line together with the curvature of the production isoquant. This is because a straight price line indicates an unrealistic perfectly elastic supply curve for each input. However, the supply curve is usually positively sloped, resulting in higher prices for increased use of an input. At the inelastic end of the production isoquant, therefore, the ratio for allocative efficiency, 0R/0Q from Fig. 3.1, will understate the firm's true allocative efficiency (Farrell, 1957, p 261).

These concepts drawn together by Farrell (1957) provide the foundations for later developments of efficiency measurement using linear programming methods. Charnes, Cooper and Rhodes (1978) were the first to label the method *Data Envelopment Analysis* with their mathematical programming model for constant returns to scale (CRS). The model was further developed to accommodate variable returns to scale (VRS) by Banker, Charnes and Cooper (1984). The computer program that conducts the calculations based on this work is produced by Coelli (1996[b]). This section has outlined some advantages and limitations of the use of technical efficiency measurement as a tool for comparing firms. Advantages and limitations of the DEA technique are set out in Chapter 2 (sections 2.2 and 2.3) of this thesis.

3.4 Stochastic Frontier Estimation[13]

The origins of efficiency measurement discussed above also influenced the development of Stochastic Frontier Estimation (SFE). SFE is the econometric (parametric) method of efficiency estimation. Traditionally, econometricians estimated production, cost and profit functions under the assumptions that producers operate *on* the functions and that they maximise or minimise accordingly. The SFE model recognises that these assumptions are unrealistic; that, due to a number of

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[13] Also referred to as Stochastic Frontier Analysis in the literature.

reasons, not all producers are successful in minimising inputs or maximising profits. Modern efficiency measurement uses econometrics to reformulate the functions into frontiers. In the case of a production frontier, the model calculates the minimum input bundle required to produce a given output. Firms who do not restrict their inputs to this minimum bundle are identified as being inefficient; their production lies beneath an estimated production frontier. The distance from the frontier is measured using a *composed* error term. Part of the error term captures the traditional symmetric random noise (v) and the other part (u) captures the inefficiency component and is one-sided. For a production frontier the error term is (v - u), is negatively skewed and has a negative mean. The production frontier model is stochastic because it recognises the existence of *random* variation in the operating environment. The inefficiency component is one-sided due to various types of inefficiency (Kumbhakar and Lovell, 2000).

Kumbhakar and Lovell (2000) set out an interesting historical development of modern efficiency measurement, with a sequence of development that clarifies the separation of efficiency measurement into the two separate streams, namely DEA and SFE. The sequence begins in the 1950s with a paper that defines technical efficiency (Koopmans, 1951), work that develops distance functions (Debreu, 1951 and Shephard, 1953), and Farrell (1957) who was the first to measure productive efficiency empirically.

Farrell's contribution to the literature is largely responsible for the emergence of both SFE and DEA. On the one stream, Charnes, Cooper and Rhodes' (1978) DEA paper is a direct extension of Farrell's paper. Development of the DEA technique followed directly from this point. However, earlier work (in the late 1960s and early 1970s), which led directly to the estimation of the SFE, was also heavily influenced by Farrell's paper. This earlier work was undertaken by Aigner and Chu (1968), Seitz (1971), Timmer (1971), Afriat (1972) and Richmond (1974). These five papers are similar in that they all estimate a deterministic production function '…either by means of linear programming techniques or by modifications to least squares techniques requiring all residuals to be nonpositive' (Kumbhakar and Lovell, 2000, p 7). Together with Schmidt (1976), these models still consisted of a *combined* error term to measure inefficiency and '…they were purely deterministic frontier models lacking a symmetric random-noise error component' (Kumbhakar and Lovell, 2000, p 7).

The above literature refined the efficiency measurement process to the point where in 1977 three independent papers were published that are now credited with SFE origination. These papers are Aigner, Lovell and Schmidt (1977), Meeusen and van den Broeck (1977) and Battese and Corra (1977). The element of the model that marks the new step to SFE lies in the error term. Common to all three papers is that they all consist of a *composed* error term, making their models stochastic, and they all develop models based in the context of production frontiers (Kumbhakar and Lovell, 2000). The SFE model is expressed as:

$$y = f(x;\beta)\cdot \exp\{v-u\} \tag{3.1}$$

where y is scalar output, x is a vector of inputs, and β is a vector of technology parameters. Thus, if $u = 0$, firms operate on the production frontier, and if $u > 0$, firms exhibit some inefficiency and operate beneath the production frontier. The model relies on a distributional assumption on u. Battese and Corra (1977) assign a half normal distribution to u, such that:

> [a]fter estimation, an estimate of mean technical inefficiency in the sample was provided by $E(-u) = E(v - u) = -(2/\pi)^{1/2}\sigma_u$ …
> (Kumbhakar and Lovell, 2000, p 9).

Meeusen and van den Broeck (1977) assign an exponential distribution to u, such

> that:
>
> $E(-u) = E(v - u) = -\sigma_u$
> (Kumbhakar and Lovell, 2000, p 9).

Either distributional assumption on u implies that the composed error $(v - u)$ is negatively skewed. In the case of Aigner, Lovell and Schmidt (1977) the paper considers both distributions for u. Maximum likelihood estimation of the model is required for statistical efficiency, and the parameters to be estimated include β, σ^2_v and σ^2_u. In the time since the SFE was originated, other more flexible distributions have been proposed with two- and four-parameters, however '…the two original single-parameter distributions remain the distributions of choice in the vast majority of empirical work' (Kumbhakar and Lovell, 2000, p 9).

From this point the SFE model was refined for panel data with fixed-effects and random-effects in order to obtain results for producer-specific estimates of technical efficiency, also known as the management effect. The assumption of time-invariant inefficiency for panel data was relaxed in the early 1990s [Cornwell, Schmidt and Sickles (1990), Kumbhakar (1990) and Battese and Coelli (1992)] due to the fact that panels that spanned very long periods made this assumption untenable. The use of a single-stage approach (Battese and Coelli, 1995), to incorporate explanatory variables into the inefficiency error component, was adopted to explain why efficiency varies through time or across producers. This extension of the model makes either mean or variance of the inefficiency error component to be a function of the explanatory variables (Kumbhakar and Lovell, 2000).

The main advantage of the SFE model is the separation of random noise from inefficiency. Unlike the DEA model where any deviation from the frontier is attributable to inefficiency, the SFE permits a *composed* error term (Worthington, 2004). Further advantage is secured when panel data (rather than cross-sectional data) is utilised. The advantages of using panel data include being able to test for endogeneity of outputs directly, having a model that is less likely to yield biased estimates of the βs, and the requirement for fewer distributional assumptions about the inefficiency term (u) than would be required with cross-sectional data. One possible limitation regarding the use of SFE is that it constructs a benchmark frontier. Farrell (1957) referred to the 'unfortunate psychological effects' when performances are measured against some unattainable ideal. Also, arguments against SFE (for producing measurement errors when using prices, costs and quantities together) only apply to estimating cost, revenue and profit frontiers. They do not apply to technical efficiency estimation using production frontiers, since input prices are not required in their estimation. This is the main reason for choosing to estimate the production frontier in this thesis and measuring technical efficiency, not allocative efficiency. The following discussion, therefore, is restricted to production frontier models using panel data.

The choices to be made when estimating a production frontier involve the decision on whether to allow technology to vary through time, or to assume constant technology, and whether to adopt a fixed-effects or a random-effects model. As mentioned above, the assumption of time-invariant technology was relaxed when using panel data. Nevertheless, it is interesting to observe the difference in the two models. Equation 3.2 shows a Cobb-Douglas production frontier with time-invariant technical efficiency, where producers $i = 1,\ldots,I$, over time period $t = 1\ldots, T$:

$$\ln y_{it} = \beta_o + \sum_n \beta_n \ln x_{nit} + v_{it} - u_i \tag{3.2}$$

Here the structure of the production technology (β_o) is assumed constant over time. Adapting the model for fixed-effects is straight forward and generates the simplest panel data model (Kumbhakar and Lovell, 2000). Equation 3.3 shows the time-invariant model in equation 3.2, with fixed-effects.

$$\ln y_{it} = \beta_{oi} + \sum_n \beta_n \ln x_{nit} + v_{it} \tag{3.3}$$

In this model $\beta_{oi} = (\beta_o - u_i)$ so that these are producer-specific intercepts. That is, the u_i are treated as fixed and are to be estimated along with the β_n s. Here there is no distributional assumption on the u_i, and the v_{it} are iid $\left(0, \sigma_v^2\right)$ and uncorrelated with the regressors. The u_i are allowed to be correlated with the regressors or with the v_{it} and are non-negative. Thus, in the fixed-effects model there will always be at least one producer assumed to be operating on the technically efficient frontier. All other producers are compared to this technically efficient producer (Kumbhakar and Lovell, 2000).

We can observe the random-effects model by allowing the u_i to be randomly distributed with constant mean and variance. In this case the u_i are uncorrelated with the regressors and with the v_{it}. There is still no distributional assumption on the u_i and they remain non-negative. Equation 3.2 is re-written as:

$$\begin{aligned} \ln y_{it} &= [\beta_o - E(u_i)] + \sum_n \beta_n \ln x_{nit} + v_{it} - [u_i - E(u_i)] \\ &= \beta_o^* + \sum_n \beta_n \ln x_{nit} + v_{it} - u_i^* \end{aligned} \tag{3.4}$$

In equation 3.4 the u_i are random and this allows for some of the x_{nit} to be time invariant (Kumbhakar and Lovell, 2000).

Time-varying technical efficiency is a more appropriate assumption for panel data particularly if the operating environment is competitive. Technical efficiency change was incorporated into models of productivity change by Bauer (1990). Earlier work on productivity change referred to the residual between an index of the rates of growth of outputs and an index of the rates of growth of inputs as 'a measure of our ignorance' [(Abramovitz, 1956) cited in Kumbhakar and Lovell, 2000]. It is now well accepted that efficiency change is a source of productivity change, and Bauer (1990) was able to decompose these by deriving '…detailed primal and dual (cost) decompositions of productivity change' (Kumbhakar and Lovell, 2000, p 308). Thus, the assumption that technical efficiency is constant over time is too strong an assumption to make.

> The longer the panel, the more desirable it is to relax this assumption. (Kumbhakar and Lovell, 2000, p 108).

Incorporating time-varying technical efficiency requires Equation 3.2 to be adjusted in the following way:

$$\begin{aligned} \ln y_{it} &= \beta_{ot} + \sum_n \beta_n \ln x_{nit} + v_{it} - u_{it} \\ &= \beta_{it} + \sum_n \beta_n \ln x_{nit} + v_{it} \end{aligned} \tag{3.5}$$

Equation 3.5 is the stochastic production frontier panel data model with time-varying technical efficiency. β_{ot} is the frontier intercept that is common to all producers in period *t*, and β_{it} is the producer specific intercept in period *t*, ie. $\beta_{it} = \beta_{ot} - u_{it}$. The introduction of time-varying technical efficiency has a cost in that additional parameters must be estimated. With an *I* x *T* panel it is not possible to obtain estimates of all $I \cdot T$ intercepts β_{it}, the *N* slope parameters β_n, and σ_v^2. Fortunately, this was addressed in the literature [Cornwell, Schmidt and Sickles (1990)] and the model was simplified somewhat to reduce the number of intercept parameters to $I \cdot 3$ as shown by equation 3.6.

$$\beta_{it} = \Omega_{i1} + \Omega_{i2}t + \Omega_{i3}t^2 \tag{3.6}$$

As with the time-invariant model, the time-variant model is adjusted for fixed-effects and random-effects, and detailed in Kumbhakar and Lovell (2000) p 109-110. In addition, these authors set out a third approach to estimating time-varying and time-invariant technical efficiency; a maximum likelihood approach.

The maximum-likelihood estimation (MLE) method can estimate the parameters of the stochastic production function by numerical maximisation of the likelihood function. Traditionally this method was computationally demanding, however the availability of new econometric software[14] has greatly simplified the process by automating the method (Coelli, Rao and Battese, 1998). According to Kumbhakar and Lovell, 2000, p 106 '…MLE is generally more efficient than either LSDV[15] or GLS[16], since it exploits distributional information that the other two do not.'

3.5 Discussion

This chapter has outlined the background to the three techniques adopted in this thesis. These techniques have been clarified to set out their strengths and limitations, as well as to provide some information of their development. Although survivor analysis cannot provide us with socially optimum efficient size, it can be utilised to determine hospital scale economies. The information garnered from survivor analysis, when added to results from frontier estimation techniques, provides another dimension to efficiency estimation. Similarly, the two frontier techniques discussed (DEA and SFE) generate results that add to understanding individual firms' relative efficiency levels. Restricting the analysis to technical efficiency estimation obviates the necessity for price data and avoids the problems associated with estimating allocative efficiency. Also, the use of panel data has been shown to produce superior results than cross-sectional data because information on many firms or producers over time is far richer than at any one point in time. The acknowledgment that firms' operations are suboptimal led to the development of the SFE and advanced production theory from *functions* to *frontiers*. For production frontiers, this means that firms do not always minimise inputs, but operate in environments that contain random variation, and are therefore prone to varying levels of inefficiency.

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[14] For example, the LIMDEP and the FRONTIER computer programs are both able to estimate SFE parameters using MLE.

[15] Least squares with dummy variables.

[16] Generalised least squares.

Chapter 4

Health Reform and the Victorian Health System

4.1 Overview

Health services in Australia are funded by State and Federal Governments (via tax revenue), private health insurance premiums as well as by individuals through out-of-pocket payments. The collection of tax revenue occurs via a compulsory Medicare levy on income tax, with extra funding taken from consolidated revenues. The extent to which each of the sources of funding is relied on for the provision of healthcare varies according to the availability of government funds and the level of private health insurance taken out. Although incentives are built into the tax system for individuals to purchase private health insurance, the decision to purchase remains voluntary.

Medicare has funded public health services in Australia since 1984. Medicare is a universal, tax-funded public insurance system that covers treatment in public hospitals and subsidises access to medical practitioners, allied health professionals and pharmaceuticals. The combination of universality, voluntary private health and co-payments for using private hospitals creates strong demand for public hospitals. Under Medicare any person, regardless of income, is entitled to free treatment in public hospitals. Furthermore, Medicare is utilised by public hospital patients who do not possess private health insurance, as well as those who have private cover, but elect to be treated as public patients.

There is a Medicare levy funded through the progressive tax system. Singles earning less than $50,000 taxable income per annum and families with a combined income of not more than $100,000 per annum are required to pay 1.5 per cent of their taxable income in Medicare levy. Singles and families earning in excess of these amounts respectively who do not hold private hospital insurance cover are required, since 1 July 1997, to pay a Medicare surcharge of an additional 1 per cent of their taxable income (Private Health Insurance Incentives Scheme fact sheet, 1997). The Medicare levy contribution towards the cost of health services accounts for only 10 per cent of Medicare's total operating cost, with the remainder coming from

Commonwealth general revenue sources (Magarry, 1999). In 2001 the level of total health expenditure in Australia represented 9.3 per cent of GDP (AIHW, 2003).

Traditionally, public hospitals in Australia were funded on an historical cost basis. This means that a hospital's budget increased each year in line with costs, and without regard to efficiency or productivity levels. Recently, however, health reforms across the nation have led increasingly to the adoption of casemix funding. Casemix funding is a method of allocating resources based on the definition and measurement of a hospital's output. Casemix funding uses sophisticated hospital output measures, such as diagnosis related groups (DRGs), which identify the different groups of diagnoses (Donato and Scotton, 1999). Since patients in the same DRG consume similar amounts of resources, DRGs are used to standardize for differences in the casemix of hospitals, thus allowing for hospital cost comparisons.

The State Government of Victoria was under considerable pressure in 1993 to undertake healthcare reforms due to that State's poor economic performance overall, as well as a perceived lack of efficiency in the operation of its acute hospital system. Casemix funding was, therefore, implemented on 1 July 1993 and has been operating in Victoria ever since. It is evident from the literature, however, that the implementation of casemix funding has met with a mixed reaction from medical practitioners and hospital administrators alike. This study uses Victoria as its focus because, although DRGs have been adopted in most Australian states, Victoria was the first state to begin data collection and the first state to implement casemix funding. The speed with which the new funding system was adopted in Victoria was indirectly driven by the need to implement expenditure cuts by that State's government. Furthermore, the commencement of the new government's term of office was the ideal time, politically, to develop strategies for health reform and budget cuts to acute hospitals.

4.2 Hospitals, Healthcare and Asymmetric Information

Healthcare markets, in general, differ from most consumer markets for goods and services because in healthcare it is not always the case that the individual consumer of health services is the payer. For the most part the payment for health service is made by a third party such as the government and/or a private health insurer. Evans

(1984) suggests that there are sources of market failure in the market for healthcare that necessitate government intervention. One of the reasons market failure exists is due to the fact that individuals receive medical treatment based on the necessary diagnosis of a medical practitioner, and not based on their own assessment of their condition. The service provided relies upon the practitioner's professional perception of an individual's needs, not on an individual's wants, which would normally be the case in goods' markets. Evans (1984) suggests that this asymmetry of information leads to consumers being unable to make judgments about the value and efficacy of health care.

> This asymmetry of information leaves open the possibility (or certainty) of severe exploitation of buyers by sellers in an arms-length, *caveat emptor* market environment.
> (Evans, 1984, p 71)

In healthcare markets informational asymmetry impacts, not only on the characteristics of a product or service, but on the *effect* that product/service (health care) has on the user. Evans (1984) notes that, in this case, buyers and sellers cannot be arms-length, since the seller is directly responsible for serving the buyer's interests. Furthermore, since health care is administered to patients who may be unconscious or unable to make use of information, even when it is provided, the postulate of consumer sovereignty becomes inappropriate.

In relation to private health insurance, market failure also arises out of asymmetrical information in the form of adverse selection and moral hazard (Evans, 1984), (Industry Commission, 1997). Adverse selection exists when the same price is charged for products or services of different quality. In the case of government purchasing of health services, hospitals (suppliers) may decide to treat only some patients, i.e. select those that will be less costly to treat, but charge the government and/or insurer (purchaser) the higher price applicable to high cost patients. This 'payoff' falls to the supplier because the purchaser does not possess all of the information available regarding treatment costs (Chalkley and Malcomson, 2000).

According to Evans (1984) moral hazard results in a tendency for expenditure on health care services to be larger due to their increased usage. This is because people with insurance may use more services than they otherwise would (Glied, 2000). In the case of suppliers, moral hazard arises when they promote the use of costly technologies to patients, knowing that the cost will be reimbursed by the insurer or Medicare. Glied (2000) promotes managed care plans as a way to overcome information asymmetry through cost-sharing provisions in indemnity insurance for patients, and utilization monitoring of costly technologies. Ellis and McGuire (1995) show that there was a moral hazard effect following the implementation of a new hospital reimbursement system in New Hampshire. Their model decomposes the impact of the reimbursement change on average resource use. That is, whether resources used in treatment increased with a more generous reimbursement system. ‘The moral hazard effect is the change in LOS[17] due to the change in treatment policy, holding patient severity (*V*) constant’ (Ellis and McGuire, 1996, p 262).

Many economists, policymakers and governments consider that government intervention in the form of health provision, funding and regulation is necessary for equity and efficiency reasons (Industry Commission, 1997, p 10). They believe that low-income earners should not be precluded from basic health care (equity); and the existence of asymmetric information suggests that consumers have difficulty in judging their own best interests (efficiency). Whilst it is generally accepted that the existence of market failure requires government intervention, it is the extent of intervention that draws considerable debate. In Australia the healthcare market has been described as one that is unique among developed nations due to the fact that it combines universal taxpayer funded health cover with a voluntary private health insurance sector (Hall et al., 1999).

4.3 Health Funding in Australia

The State and Territory governments are responsible for and administer public hospital services in Australia. These responsibilities include psychiatric hospital services, public health services such as school, dental, child and occupational health, and the control of diseases. Other major responsibilities of the State/Territory governments are the provision and regulation of nursing homes and control over the number of private hospitals, including bed numbers and locations (Clinton et al., 1995, p 34).

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[17] Length of stay.

The manner in which health funding is distributed in Australia has been the subject of some criticism. Essentially, the Federal Government controls how much funding is distributed to the States and, through Medicare, forces the States to provide free hospital care to public patients. At the time of the introduction of casemix funding specific purpose payments were issued to the States, with the distribution based on fiscal equalisation, and not on a State's ability to generate revenue.

A major source of friction between the Federal and State/Territory governments has been the existence of vertical fiscal imbalance. This occurs because under the Australian Constitution, States are limited in their ability to generate revenue via taxation. In order, therefore, for States to remain viable they must rely, to a great extent, on conditional grants from the Federal government to fund health and other programs administered by them (Donato and Scotton, 1999). Section 96 of the Constitution gives the Federal government the power to make these grants, even though the Federal government does not have explicit powers to administer the provision of public hospitals. Furthermore, an amendment to the Constitution in 1946 (section 51 xxiii A) confers powers on the Commonwealth with respect to pharmaceutical, sickness and hospital benefits, medical and dental services. Under this amendment, and under Section 96, the Commonwealth has been able to influence health policies implemented by the States based on its leverage and authority (Bloom, 2000).

The universal health system is administered by Health Care Agreements (HCA) (formerly known as Medicare Agreements), each having a duration of five years, between the Commonwealth government and the six State and two Territory governments. The first HCA began in 1998 and expired in 2003 (Magarry, 1999). The principles under which the negotiated HCAs operate are currently contained in the *Health Care (Appropriation) Act 1998*. These include the provision of public hospital services free of charge to public patients, access to treatment based on clinical need, and equitable access to services for people regardless of their geographical location (Maskell-Knight, 1999). Each State and Territory agrees to abide by certain criteria over each agreement's five-year duration to enable the Federal Government to implement its funding policy. The current Agreement was structured in such a way that it now addresses the problem of cost shifting by the States, with the insertion of a penalty clause.

Cost-shifting was an inherent part of the 1993-98 Medicare Agreements due to the existence of barriers that prevented any exploration of possible improvements in health care effectiveness (Magarry, 1999). In an attempt to halt this cost-shifting behaviour, the Commonwealth imposed a cost-shifting penalty on the States in the context of the 1996 Budget. The penalty clause has also been inserted in the HCA and states that the Commonwealth Minister may reduce funding if the Minister perceives that the Agreement has been breached by any deliberate cost-shifting by the States (Maskell-Knight, 1999). However, it has been argued (Magarry, 1999) that these penalties have resulted in a reduction in the level of cooperation between the States and Territories and the Commonwealth, and have had no real effect on the management of the health care system.

The agreements also contain provision for demand growth risk. Under the first HCA the Commonwealth and States negotiated a different risk-sharing package, consisting of the Commonwealth accepting a 2.1 per cent per annum risk for demand growth. This is growth in excess of population and ageing and also in excess of output costs and insurance participation rate changes (Maskell-Knight, 1999).

In the lead up to the 2003-2008 HCA, negotiations between the Federal and State Health Ministers centred on making significant changes. In particular the Ministers acknowledged that past agreements focused more on health funding than they did on health outcomes [Paterson (2002), Reid (2002)]. Evidence on the current HCA suggests that this focus has not altered. The then Federal Health Minister’s Media Release of 29 August, 2003 notes that the States will be able to run their hospitals more efficiently and with greater certainty since funding has now been put in place for 5 years instead of the previous 1 year. The Minister also mentions an increase in funding to the States of $10 billion (17 per cent above inflation) (Patterson, 2003).

As the level of funding has altered over the years, so too has the sophistication of the allocation of funds. State governments have had to invent more efficient ways of allocating funds to public hospitals within their borders. Cutbacks in health expenditure at the Commonwealth level mean that ultimately hospitals have become more accountable for the funding that they receive. Hospitals can now be compared for relative efficiency, and funds can be directed to those hospitals that have been successful in reducing operating costs. This was not possible in the past, in the absence of any standardised measure.

The development of DRGs has enabled State Governments to now compare acute hospitals for efficiency such that reduced government funding can be distributed according to performance, as opposed to historical cost. DRGs have been implemented in the Australian health system to varying extents. Some states use DRGs as a management and information tool, whilst others have adopted DRGs for payment purposes.

4.4 Casemix Funding using Diagnosis Related Groups

Originally developed in the United States, DRGs were designed to facilitate hospital management to measure and evaluate hospital performance (Fetter, 1991). This process became necessary shortly after the implementation of Medicare in the U.S. in 1965 due to the requirement for hospitals to undertake utilization review and quality assurance as a condition for receiving Medicare funds. Over the first decade of Medicare in the US, DRG measurement developed into a means of simulating the open market to the extent of establishing a rate of payment that prevented hospitals operating at high production cost levels. It was evident that there existed an absence of cost and quality information in health care, which would otherwise provide health consumers with the necessary means of selecting among hospitals as they would in a competitive market. Furthermore, in many instances health consumers were not required to pay for the services they received and, therefore, were less inclined to attach importance to hospital cost reductions. It was proposed that this cost containment initiative, which was designed to put a cap on hospital revenue, be combined with a peer-review mechanism to ensure that the minimum level of service quality prevailed (as would be the case if all information was available to consumers) (Fetter, 1991).

In Australia the use of DRGs, and applying similar measurements of hospital activity, developed in response to the prospect of reduced government funding due to

State budgets being in deficit. Cost containment policies were in place in Victoria for almost twenty years prior to health reforms (Duckett, 1994). Steps were taken to commission Prof. R.B. Fetter (Yale University) and Prof. G.R. Palmer (University of NSW) in 1985 to provide advice on the applicability of DRGs to the Australian system. Various other reports were commissioned in the early 1990s that were aimed at developing a 'national DRG grouper and an Australia-wide costing project' (Duckett, 1994, p 3). One such report commissioned by the Commonwealth Department of Community Services and Health was a major contributor to the development of the use of DRGs for casemix funding. Scotton and Owens (1990) provide a clarification of the issues and sentiment behind the rationale for introducing casemix funding using DRGs in the first instance.

> The central idea behind the use of case payment for hospital reimbursement is that payment geared to **output** will result in more efficient performance than other formulae. The key concepts involved are the **treated case** as the payment unit and a **casemix model** which enables cases with different treatment requirements to be categorised and costed.
> (Scotton and Owens, 1990, p 1)[18]

It was found that, at least for an interim period, the US DRG groupings could be used in the Australian context, although it was recognised that the financial information systems in Victoria needed to be further developed. Indeed, it was the lack of available financial data that prevented many States from adopting the DRG method sooner. In Victoria the Health Department began to publish the *Victorian Hospital Comparative Data* in 1987/88, which provided data on comparative hospital efficiency as measured by cost per DRG-weighted patient treated. This data was initially only used for comparison purposes and not for funding purposes. In 1992 the report of an independent review of Victorian Health Services, submitted to the then Labor Government, recommended a four-year phased introduction of casemix funding for hospitals of more than one hundred beds. Due to a general expectation that the impending election would result in a change of government, hospitals took little action at that time to prepare for a move to casemix funding. With the election of the Kennett Liberal Government in October 1992, and the Commission of Audit

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[18] Words in bold are as per original cited.

[refer section 4.7] that followed, casemix funding was subsequently implemented on 1 July 1993.

The basic philosophical argument put forward by proponents of the DRG formulae was that by introducing casemix funding using DRGs, hospitals could be compared for efficiency, with the most efficient being rewarded, and those that were inefficient being penalised. In this way the public would not be expected to subsidise the operations of inefficient hospitals, since penalties took the form of reduced government funding (Averill et al., 1991, p 220). Furthermore, it was suggested that the failure to reward efficient providers could result in reduced motivation of all providers to improve their performance, resulting in the prospect of spiralling costs.

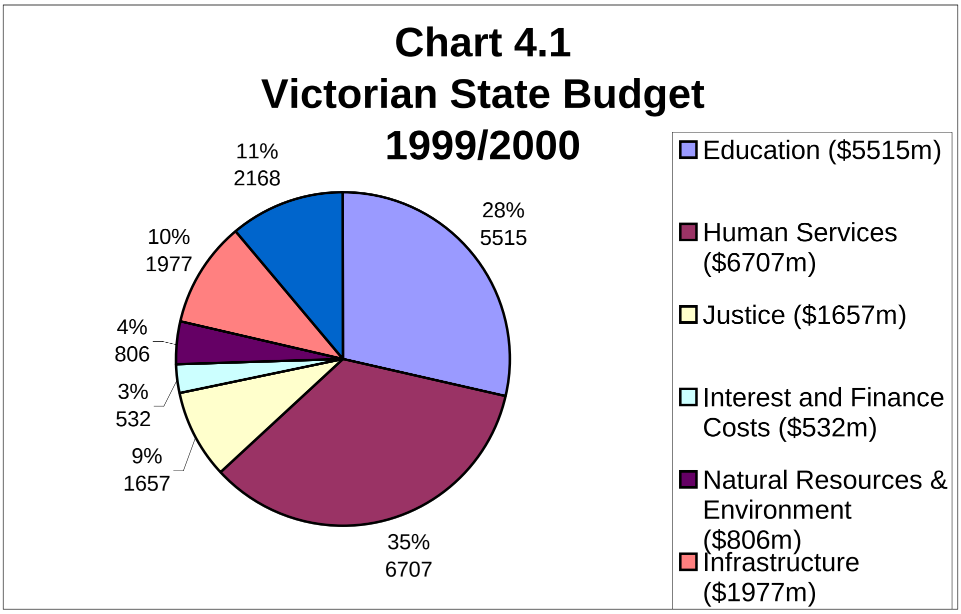
4.5 Structure of Victorian Health

The Victorian health system is administered by the Department of Human Services (DHS), which was formed in April 1996 by the amalgamation of the former Department of Health and Community Services with the Office of Housing and the Office of Youth Affairs (DHS, 2001[a]). There are nine divisions under the DHS.

The Acute Health Division has program responsibility for purchasing services from public hospitals, which accounts for almost 50 per cent of the Department's budget. Aged, Community and Mental Health Division is made up of Mental Health Services, Aged Care Services and Primary Health Care. The Community Care Division was formerly known as Youth and Family Services, and is responsible for supporting families. DisAbility Services Division provides and funds services for people with intellectual, physical, sensory and neurological disabilities and acquired brain injury. The main aim of the Office of Housing is to cost effectively provide affordable housing assistance to those most in need of such assistance. The Policy Development and Planning Division consists of a Tax Implementation Unit and a project known as Victorian Nurse Practitioner. The Public Health Division is charged with responsibility for the health of populations, rather than treatment of individuals. It is also concerned with the underlying causes of ill health, preventative strategies, and has a strong scientific, analytical and statistical basis. The Resources Division deals with the dissemination of information to Agencies, as well as the development of privacy principles. The Rural Health Services Unit develops and coordinates the strategic response to rural health issues and provides the lead role in the development of modern health services in small rural communities (DHS, 2001b).

4.6 Acute Health Division

In the 1999/2000 Budget, the State Government of Victoria allocated $6,707 million to the Department of Human Services. As shown below in Chart 4.1, this amount represents 35 per cent of the total Victorian State Budget.



Source: Victorian Budget Papers (1999/2000) p10

For the purpose of this study, the division within Human Services that is of particular interest is the Acute Health Division. This division accounts for approximately 50 per cent of the Department's budget and, therefore, approximately 17 per cent of the State Government's overall financial commitment. Acute Health is responsible for funding the delivery of acute and sub-acute services, the provision of ambulance services, and ensuring the provision of adequate and safe supplies of blood and blood products (DHS, 99/00, p10). Within these parameters Acute Health delivers strategies to promote efficiency and accountability in public hospitals, and ensures the continued development of the casemix funding system. It is also charged with improving ambulance responsiveness, inpatient and rehabilitation services, maternity care and the general delivery of healthcare in Victoria.

Prior to the introduction of casemix funding, Victorian hospitals were funded on historical cost, based on inputs such as salaries and pharmaceuticals. Any budget reductions made during this period usually resulted in reduced services. This was followed by the period in the mid-1980s when detailed input controls over hospitals began to be relaxed and hospitals moved to 'global budgeting'. Under this system hospitals were able to shift funds between the various classes of inputs, and between salary and non-salary expenditure. Although this change was accompanied by an increasing emphasis on measuring a hospital's total activity levels, the link between inputs and outputs remained weak. This funding system (and varying political strengths within the hospital) rewarded advocacy skills rather than promoting efficiency of input use (Lin and Duckett, 1997, p 48).

4.7 Health Reforms

There are several reasons why health reforms were undertaken in Victoria. One reason was that in the period 1992-93 to 1994-95, State debt exceeded $30 Billion (Victorian Budget Papers, 1999/2000, p 5). The newly elected Liberal coalition was committed to reducing this debt and so undertook expenditure cuts. As mentioned, Acute Health absorbs approximately 17 per cent of the State's budget, and so cuts in this area were viewed as having the most effect on debt. Consequently, 30 per cent of the total State budget reduction was achieved solely by funding cuts to Acute Health (Duckett, 1994, p 19). At the same time there was evidence that Victorian hospitals were less efficient than hospitals in the other Australian states. Shortly after the 1992 state election the Liberal coalition government appointed a Commission of Audit whose purpose was to assess and report on state finances. The Report presented to the Premier in 1993 'claimed that Victorian acute hospitals were 18 per cent more expensive than hospitals in other states' (Lin and Duckett, 1997, p 49). The Report further claims that 'with the introduction of output-based funding using casemix data, annual efficiency gains could be as much as 14 per cent ($373m) of the current hospitals (sic) budget if a new hospital funding base is set based on comparable NSW benchmarks' (Victorian Commission of Audit, 1993, p 81). The Report also found that a significant determinant of cost inefficiencies in Victorian hospitals, relative to those in New South Wales, was excessive staffing levels. The Government also had evidence from the Commonwealth Grants Commission, which had collected data that corroborated the Commission of Audit's findings, that

Victorian hospitals were relatively inefficient. In view of these findings and in view of the necessary expenditure cuts, it was considered that an across-the-board funding reduction would not be equitable to those hospitals operating efficiently. The funding cuts were thus targeted at hospitals found to be operating inefficiently.

A further reason put forward for reform of the health sector was the existence of growing hospital waiting lists. Of the 30,000 people on waiting lists in Victoria, 5 per cent were in need of Category 1 urgent care. Since the Government had made pre-election promises to reduce these waiting lists, it had to also ensure that funding cuts would not have the opposite effect. Thus, the objectives of reform were:

- To introduce a fair basis for funding hospitals in the context of an overall budget reduction;
- To improve the efficiency of public hospitals, and;
- To provide for an expansion in the number of patients treated and thus to allow a reduction in waiting lists.
  (Duckett, 1994, p 20)

According to Duckett (1994) it was the Government's intention to introduce casemix funding as the means of restructuring hospital funding arrangements so that the right financial incentives could be put in place to achieve these objectives. It could be argued, however, that casemix funding was the means of achieving considerable reductions in government expenditure at a time when the newly elected government was at the height of its popularity. Health reforms were also necessary due to the Federal Government's broader concerns for microeconomic reform. That is, the provision of health care was not immune to the legislative amendments to anti-trust legislation that focused on increased competition and efficiency in Australia generally.

4.8 Victorian Health in a Competitive Environment

Health and community services in Australia received considerable attention with regard to conforming to new competition legislation. The *Trade Practices Act (1974)* was amended in 1995 to reflect the need for a movement toward increased competition in Australian industry (private and public). The aim of the change in anti-trust legislation is to eliminate anti-competitive conduct resulting in misallocation of resources and income transfers. Central to this change was the 1993 report of the independent committee of inquiry, headed by Professor Fred Hilmer and entitled *National Competition Policy* (Hilmer, 1993). The committee's report provided the basis on which new competition legislation was later able to be promulgated in the form of the *Competition Policy Reform Act (1995)*. This section outlines the impact that the new policy environment had on Victorian public hospitals.

In 1996 the Victorian Department of Human Services (DHS) published a discussion paper seeking submissions concerning health insurance reforms for private patients in public hospitals. The paper notes that the principles of the National Competition Policy are consistent with a more level playing field between public and private hospitals. The paper then discusses the Victorian public hospital system in light of the new competition policy's impact on the private health insurance industry (DHS, 1996).

Under the Commonwealth reforms of the private health insurance legislation[19], the former basic table minimum benefits payable to insured persons treated in any registered hospital were replaced with applicable benefit arrangements (ABA). These are more flexible than the basic table, and can provide cover in all hospitals. Another significant change brought about by these reforms is that public and private hospitals can now enter into contracts with insurers (Hospital Purchaser-Provider Agreements [HPPAs]), which set out the treatments that the insurer agrees to cover (DHS, 1996).

With respect to complying with the principles of the National Competition Policy, the DHS proposed that increased competition between private and public hospitals could be addressed by developing a more equitable funding system. The various funding systems put forward for comment at the time were all designed so that both types of hospital could compete for private patients on an equal footing, eliminating the 'unfair advantage' exercised by public hospitals (DHS, 1996).

---

[19] The legislation governing private health insurance is enshrined in the *National Health Act (1953)*, and requirements governing health insurance were contained in the Medicare Agreement current at the time of reforms. These requirements and provisions dictate the way in which benefits are to be paid to members who receive treatment in public hospitals.

Briefly, the treatment of increased competition between private and public hospitals was designed to adhere, in particular, to the issue of competitive neutrality between private and public sector organisations:

> - Moving to full cost recovery charging is broadly consistent with the National Competition principles of competitive neutrality and pricing transparency.
> - The Australian Private Hospital Association has suggested that the current subsidised public hospital prices give public hospitals an unfair advantage when competing for private patients.
> - Despite raising concerns about unfair advantages enjoyed by public hospitals, the private hospitals sector is likely to be critical of any attempts by public hospitals to compete directly for full cost recovery patients.
>
> (DHS, 1996, p 13)

The Victorian legislation governing public health is the *Health Act (1958)*. In 1998, following the adoption of National Competition Policy, and in response to its recommendations and requirements, the Department of Human Services published a Discussion Paper on the review of the *Health Act (1958)* (DHS, 1998). This Act deals mainly with public and environmental health, radiation safety, pest control, infectious diseases, vaccines and health information. In relation to prescribed accommodation, the review specifically states that public hospitals or health service establishments registered under the *Health Services Act (1988)* are exempted from Part 12 of the *Health Act (1958)* (DHS, 2000, p 63).

Under the *Health Services Act (1988)* Part 6 deals with Health Purchasing Victoria (HPV). As it stands in 2004, Section 130 of Part 6 states that HPV is a public authority and it represents the Crown. The outline of functions of the HPV clearly shows its relationship to Victorian public hospitals. Section 131 outlines these functions as follows:

> HPV has the following functions –
>
> (a) to supply or facilitate access to the supply of goods and services to public hospitals and other health or related services on best value terms;
>
> (b) in relation to the supply of goods and services to public hospitals and the management and disposal of goods by public hospitals -

   - (i) to develop, implement and review policies and practices to promote best value and probity; and
   - (ii) to provide advice, staff training and consultancy services;

(c) to provide advice, staff training and consultancy services in relation to the supply of goods and services to, and the management and disposal of goods by, health or related services other than public hospitals;

(d) to monitor compliance by public hospitals with purchasing policies and HPV directions and to report irregularities to the Minister;

(e) to foster improvements in the use and application of purchasing systems and trading by electronic transactions by health or related services;

(f) to establish and maintain a database of purchasing data of public hospitals and supply markets for access by public hospitals;

(g) to ensure that probity is maintained in purchasing, tendering and contracting activities in public hospitals;

(h) any other functions conferred on HPV by this or any other Act.
(*Health Services Act, 1988*)

The Act also sets out Health Purchasing Victoria's responsibilities under the new Competition Code under Section 134O:

(1) Any act or thing of or relating to HPV in carrying out its functions or exercising its powers under this Part is authorised for the purposes of Part IV of the Trade Practices Act 1974 of the Commonwealth and the Competition Code within the meaning of the **Competition Policy Reform (Victoria) Act 1995**.

(2) Any act or thing of or relating to a public hospital or a member of a board of a public hospital or a person who is engaged or employed by a public hospital in complying with an HPV direction or a purchasing policy of HPV under this Part or in relation to the purchase by, or supply to, a public hospital of goods or services in accordance with this Part is authorised for the purposes of Part IV of the Trade Practices Act 1974 of the Commonwealth and the Competition Code within the meaning of the **Competition Policy Reform (Victoria) Act 1995**.
(*Health Services Act, 1988*)

In terms of the overall health services policy review in Victoria, a Final Report by Casemix Consulting and Phillips Fox, solicitors, was presented to the Victorian Health Minister in November 1999. Pursuant to the National Competition Principles Agreement, the report analyses the various Victorian health Acts and Regulations for evidence of any restriction of competition. Under the Agreement's guidelines legislation should not restrict competition unless it can be demonstrated that:

> - the benefits of the restriction to the community as a whole outweigh the costs; and
> - the objective of the legislation can be achieved only by restricting competition.
>
> (Casemix Consulting, 1999, p 1)

The recommendations made in that final report were varied and relate to the review of the *Health Services Act,* 1988, the *Health Services (Private Hospitals and Day Procedure Centres) Regulations,* 1991, and the *Health Services (Residential Care) Regulations, 1991*, all of which contain legislative restrictions on competition in public and private markets for health care.

4.9 AN-DRGs and Casemix Funding in Victoria

The first version of DRGs adopted by the Victorian Government in 1993 was Australian National Diagnosis Related Groups (AN-DRGs). Using this particular measure the Minister for Health was able to implement casemix funding so that hospital services followed patients, rather than hospitals receiving funding as institutions in control of their own budgets. As casemix funding was espoused by the Minister, it was a matter of putting the patients' needs ahead of all else (Stoelwinder and Viney, 2000, p214).

Since 1993 DRG codes have been altered to address certain requirements of the medical profession and to reflect advances in medical technology and the introduction of new diagnosis and procedure codes (Commonwealth of Australia, 1998, p1). In particular, the Australian Casemix Clinical Committee (ACCC), which comprises clinicians of all disciplines including medical, nursing and allied health, has been the main driver for changes to AN-DRGs. There have been four versions of DRGs since 1993, and the main reason for this has been the need to improve their clinical coherence (Reid et al., 2000, p29). As part of the more recent review process (Australian Refined (AR) DRGs version 4) the definition of severity of illness was improved to better reflect resource use. The measure, known as complications and comorbidities (CCs), has a severity level assigned to it such that patients with a number of CCs are likely to have more severe illness and to be more resource intensive to treat. A recent study (Reid et al., 2000) into the performance of the various versions of DRGs has resulted in the finding that the most recent version (AR-DRG version 4) is a more significant improvement on versions 1.0 to 3.0. The Commonwealth released AR-DRG version 4 over a period of 2 years from April 1998, and AR-DRG version 4.1 cost weights were scheduled to be released in March 2000 (Commonwealth of Australia, 1998, p 42).

Victoria adopts the various versions of DRGs as they become available. However, there has been considerable backlash against casemix funding from some quarters that claim that the new funding system has had a negative effect on hospital outcomes and quality of care. As mentioned [refer to section 4.7], the newly elected government needed to overcome the problem of budget cuts resulting in longer waiting lists. It was decided that the best way to achieve this was to provide an incentive to hospitals to increase throughput. Extra revenue from an additional throughput pool could be achieved by hospitals that were able to meet their waiting list performance criteria. However, this incentive proved to be too effective by the second year of operation, when the increase in throughput was double that previously anticipated by the Department. This extra throughput resulted in additional pressure on funds in the pool, and meant that there was difficulty keeping within the pool's budget. In response to this situation the Government decided to limit any hospital's call on the pool to 5 per cent of its base throughput target. The result of this decision, however, was to reduce patient throughput as a consequence of budget cuts; something that the additional throughput pool was designed to overcome (Stoelwinder and Viney, 2000, p215).

Reductions in throughput led eventually to bed closures, staff sackings and the sudden increase of people on hospital waiting lists. Casemix funding received significant negative media attention that held the Government responsible for its implementation. That is, although budget cuts were responsible for bed closures, it was the fact that budget cuts were undertaken within the new casemix funding regime that drew criticism from the media and political opponents. Commentators took the view that casemix funding led to budget cuts and, therefore, casemix funding was responsible for bed closures and increased waiting lists. The additional throughput pool was subsequently abolished in 1995/96 (Duckett, 2000).

As the purchasing arrangements currently operate in Victoria, hospitals receive a capped annual budget from which to provide inpatient services. That is, hospitals know in advance the total number of WIES annually that will be funded. It is therefore necessary that hospitals plan ahead to ensure that funding will be available for the full year. There is '…no capacity for additional funding in the event of budget overrun' (Brook, 2006, p4). According to the Victorian Department of Human Services, budget caps dictate planning measures by hospitals which ensure efficiency in resource utilisation.

> …the system utilises capital and recurrent resource restrictions to ensure that duplication, particularly of highly expensive high technology care, is minimised…[and]…It [casemix funding] emphasises technical (cost) efficiency and…has been instrumental in transforming Victoria's hospital system from arguably Australia's least efficient, to a highest level of efficiency.
> (Brook, 2006, p4)

In tandem with budget caps, the author states that there are in place price signals, through bonus and penalty arrangements, '…which encourage desired policy outcomes – such as meeting emergency and elective surgical waiting time targets' (Brook, 2006, p4). Thus, on the one hand budgets are capped to fund a given number of WIES annually and, on the other hand, hospitals are required to maintain waiting list targets which, if they are successful, may lead to budget overruns. Under these circumstances it is probable that hospitals will allow waiting lists for non-emergency elective surgery to grow rather than risk receiving insufficient funding for a given year.

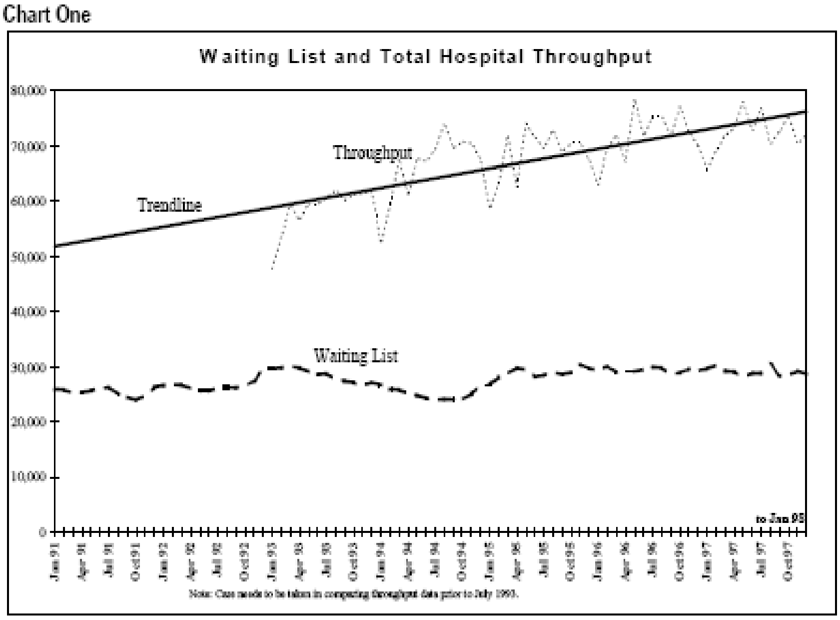
Patients are categorised into clinical categories when they are placed on the waiting list. The three categories were established to identify the relative clinical priority of patients needing hospital admission. These categories are:

> Category One: Admission within 30 days desirable for a condition that has the potential to deteriorate quickly to the point that it may become an emergency.

> Category Two: Admission within 90 days for a condition causing some pain, dysfunction or disability but which is not likely to deteriorate quickly or become an emergency.
>
> Category Three: Admission at some time in the future acceptable for a condition causing minimal or no pain, dysfunction or disability, which is unlikely to deteriorate quickly and which does not have the potential to become an emergency.
> (Clarke and Bennett, 1998, p16)

The Review of Elective Surgery Waiting Lists was set up in 1998 to determine whether there was any evidence to support allegations made by the Australian Medical Association (AMA) of widespread manipulation of hospital waiting lists throughout Victoria (Clarke and Bennett, 1998). The Review's findings, that this was not the case, were presented to the Victorian Minister for Health in September 1998. The findings show that 'There has been a steady increase in both the total number of patients treated in Victoria's public hospitals and in elective surgery patients since 1991' (Clarke and Bennett, 1998, p24). This is represented by two charts which show a comparison of waiting lists and throughput trends (reproduced below).

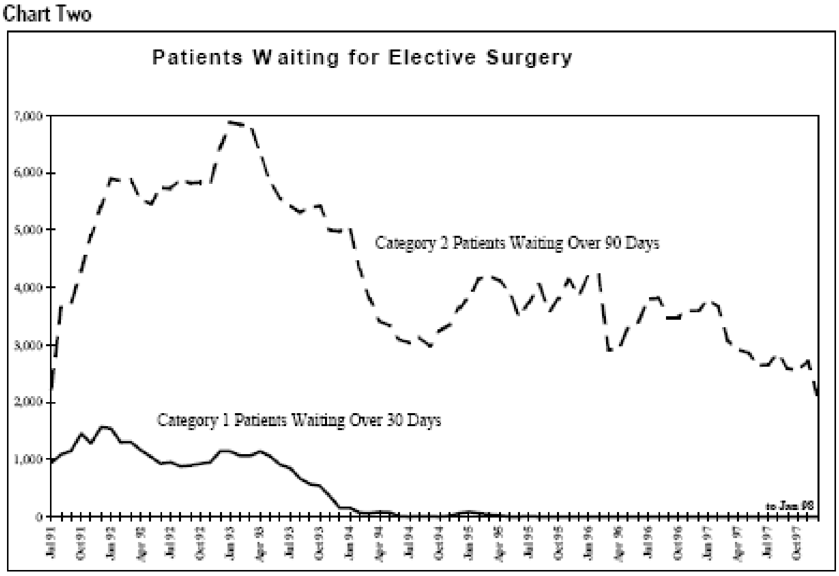
Chart 4.2 – Victorian Waiting List and Total Hospital Throughput Jan. 91 – Oct. 97



Source: Clarke and Bennett, 1998, p24

According to Chart 4.2 throughput fluctuates widely over a rising trend over the period to meet the increased demand for hospital services. It is also apparent from Chart 4.2 that there was an initial reduction in the waiting list over 1993-1994, but then the waiting list rose again to slightly more than pre-existing levels in 1995. Chart 4.3 shows the separation of Category One and Category Two patients on the waiting list.

Chart 4.3 – Victorian Patients Waiting for Elective Surgery
Jul. 91 – Oct. 97



Source: Clarke and Bennett, 1998, p24

It is clear from Chart 4.3 that the number of Category One and Category Two patients on the waiting list fell following the implementation of casemix funding in July 1993. Taking Charts 4.2 and 4.3 together it is apparent that, because the total waiting list rose to above pre-existing levels, it must be the case that Category Three patients on the waiting list rose over the period. These are not reported separately in the Review’s findings. Also the two charts show different scale on the vertical axis. Chart 4.3 appears to show relatively large fluctuations, however for Category Two data the change from peak in 1993 to trough in 1997 is less than 5,000 patients. These data confirm that the number of Category Three patients on the waiting list did in fact rise over the period. The incentives in place to reduce Category One and Two patients on the waiting list appear to be working, however at the expense of Category

Three patients. The result, therefore, is that there has been a deterioration of the total waiting list under casemix funding with budget caps.

In the first two years of operation, casemix funding was comprised of a number of component grants. Table 4.1 shows the change in component grants between the years 1993-94 and 1994-95. The compensation component was only intended for the first year of operation of casemix funding, as a transitional grant from the old funding system to the new. It was calculated on the difference between funding received by hospitals pre-casemix funding (1992-93) and that received post-casemix funding (1993-94) (McLean, 1994). This component resulted in the removal of the effect of casemix funding in the first year of operation. Clearly, without this compensating grant, funding would have decreased by approximately 8 per cent between 92-93 and 93-94.

Table 4.1: Victorian Casemix Funding Components 1993-94 to 1994-95

Component Grants	Proportion of Funding 1993/94	Proportion of Funding 1994/95
Non-admitted patients	18	17
Overhead	27.1	26
Specified/training grants	13.4	16
Compensation	8.1	0
Variable Payments	33.4	41
Total	100	100

Source: McLean, 1994, p 34.

According to Table 4.1, with the exception of the overhead and non-admitted patient components, the remaining two components increased proportionally in the second year of casemix funding. The largest increase occurred for variable payments. These include payments for public hospital medical officers, unit DRG reimbursements to hospitals, rural/isolated patient transfer costs and nursing home type patients. With regard to Group E hospitals, located in rural Victoria, an additional $50 per patient treatment episode was paid by DHS ‘to reflect higher staffing costs in smaller institutions’ (McClean, 1994, p 34).

The specific period that this thesis investigates is 1992/93 to 1995/96. Over this period there was some change in expenditure trends. Duckett (2000) shows, by constructing an index, how budgeted expenditure for acute health services in Victoria fell by 9 per cent initially between 1991/92 and 1993/94, and rose by 9 per cent above 1991/92 levels in 1996/97 (Duckett, 2000, Table 8.1, p155). The same table shows an index of separations which rises steadily from 100 to 131. However, the author states that separations rose over the period by 75 per cent, as a response to the introduction of casemix funding. He notes, nevertheless that some of the increase in activity may be due to the reclassification of some outpatients to inpatient status. Duckett (2000) also notes that the WIES figure, which was introduced in 1993/94, rose at a much slower rate over the period. The index for WIES rises from 100 to 109.

> The extent of actual versus nominal growth is difficult to estimate. Assuming that all the activity increase is real, the costs per separation have declined by 25 per cent over the period 1991/92 to 1996/97.
> (Duckett, 2000, p156).

Graph 4.1 has been constructed using historical data[20] from the Victorian Government's Statement of Finances 2005-06, Budget Paper No. 4 (State of Victoria, 2005-06). Over the period 1992/93 to 1995/96 Graph 4.1 shows an initial significant slowing down of expenditure, followed by a reduction of health expenditure in Victoria. Visually it is apparent that during the period prior to budget cuts and the implementation of casemix funding, expenditure increased steadily. It is also apparent that from 1996/97 the rate of growth of expenditure surpasses earlier growth (that is, the gradient becomes steeper).

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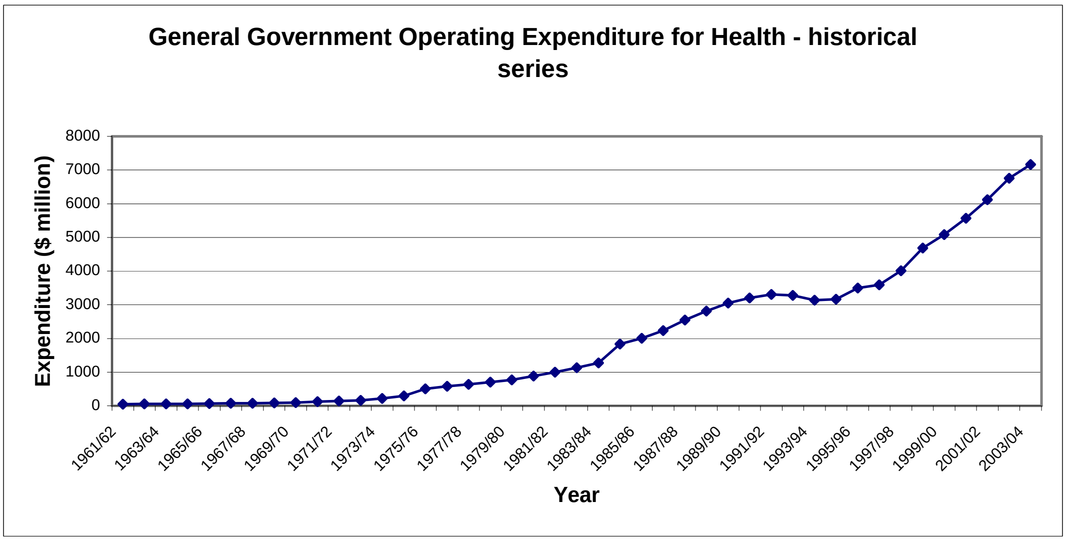
[20] One of the difficulties with obtaining a dependable data series for Victoria over this period has been the lack of uniform data collection by the relevant authorities. The data that forms the content for Graph 4.1 is reproduced from Victorian Budget Papers. Its original source is the Australian Bureau of Statistics, Catalogue 5512.0. No mention is made as to whether the expenditure is in current or constant dollars.

Graph 4.1: Victorian General Government Operating Expenditure for (Total Health Expenditure) 1961/62 to 2003/04 – historical series



Source: Victorian Budget Papers (2005-06)

Graph 4.1 shows the existence of budget cuts over the period 1992-1995; however it is not apparent to what extent acute care hospitals were affected because the graph plots total health expenditure in Victoria. Nevertheless the graph is interesting and reflects budget cuts and health reforms in Victoria.

Walsh (1996) outlines some of the achievements under casemix funding in Victoria and suggests that since its inception hospital productivity has increased by 15 per cent, with a funding reduction of approximately 10 per cent. He also notes that length of stay has fallen, with an increase in day-only cases of 30 per cent. The author also goes on to list some disadvantages of casemix funding, including that hospitals that specialise in intensive care patients are disadvantaged by its use due to their increased resource use. This has since been addressed to some extent, however, by the new DRG coding system. Fox (1996) reports that in his experience in Victoria there has been a dramatic efficiency improvement under casemix funding.

> The average cost per DRG weighted inpatient at both the Alfred and Box Hill Hospitals has substantially reduced over the past two years.
> (Fox, 1996, p 135)

These two references to 'efficiency' are based on the same incorrect presumption that is evident in a significant amount of the literature on casemix funding. DRG costs are not a measure of efficiency in themselves; merely a way to compare costs between hospitals. Technical efficiency, however, is measured by the number of inputs that are used to produce health outcomes, or how successful a hospital is in minimising inputs to produce the same outputs. Efficiency measurement, which allows us to compare the performance of hospitals, can be made using frontier methods, with DRG costs as output weights; one of the purposes of this study.

4.10 Application of Casemix Funding to Rural Victoria

The implementation of casemix funding for acute health services in Victoria was anticipated to impact on small rural communities. In 1993 the Victorian Small Rural Hospitals Task Force was established ‘to review the progress and difficulties of small rural hospitals in Victoria following the introduction of casemix funding’ (DHS, 2002, p3). There were 57 small rural hospitals each with 30 or fewer beds in 1994. These hospitals are classified as Group D and Group E hospitals and include Multi-Purpose Service and Healthstreams agencies (DHS, 2002). The Taskforce acknowledged the diverse nature of rural Victoria in terms of topography, geography and socio-economic factors. It also acknowledged that small rural hospitals should provide services based on identified community needs. The Taskforce noted that communities should be made aware of the benefits associated with the redistribution of resources away from ‘high cost underused bed-based services to more cost effective and accessible community based services’ (DHS, 2002, p 3). As outlined in section 4.9 and Table 4.1 variable payments to hospitals included a payment for rural/isolated patient transfer costs. This payment was targeted specifically toward the cost of ambulance transfers between hospitals, which are more prevalent in remote rural communities. The amount in both years in Table 4.1 represents approximately 0.1 per cent of funding (McLean, 1994).

4.11 Victorian Public Hospitals

It is interesting to note that hospitals located in the four Melbourne metropolitan regions serviced a population of 3,321,666 residents in 1997, whilst hospitals located in the balance of Victoria together serviced over 1.2 million residents (28 per cent of the resident population) (ABS Cat. 3234, 1997). Table 4.2 below shows a breakdown of the resident population located in Melbourne and the ten statistical divisions outside of Melbourne in 1997.

Table 4.2: Estimated Resident Population in Melbourne and Non-metropolitan Victoria, 1997

Statistical Division	Estimated Resident Population
Melbourne	3 321 666
Non-Metropolitan Regions	
Barwon	240 906
Western District	100 125
Central Highlands	135 443
Wimmera	52 027
Mallee	87 590
Loddon	158 656
Goulburn	184 141
Ovens-Murray	89 698
East Gippsland	81 002
Gippsland	153 894
Total	**4 605 148**

Source: ABS Cat. No. 3234.2, 1997

Appendix IV to this chapter sets out a summary table of the raw data utilised in this thesis[21]. The data is grouped into hospital size (A, B, C, D and E)[22] with each hospital named. The period of observation is 4 years (1992/93 to 1995/96) and there are four characteristics for each hospital (two outputs and two inputs). These are WIES, inpatients treated, EFT staff number (non-medical staff) and average available beds. Table 4.3 is constructed from the same data, and provides a summary of the number of hospitals in each group over the period.

Table 4.3: Summary of Victorian Hospitals by size 1992/93 – 1995-96

Group	1992/93	1993/94	1994/95	1995/96
‘A’ Teaching Hospitals	16	16	16	16
‘B’ Large Regional Base and Suburban Hospitals	22	22	21[a]	21[a]
‘C’ Regional General Hospitals	24	24	23[a]	23[a]
‘D’ Area Hospitals	22	22	20[a]	20[a]
‘E’ Local Hospitals	33	31[a]	22[b]	21[c]
Total	**117**	**115**	**102**	**101**

Source: Victorian Hospital Comparative Data, 1992/93 – 1995/96

a = reduction from initial year due to closures, b = 5 closures, 6 amalgamations, c = 5 closures, 7 amalgamations.

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[21] Source is the Victorian Hospital Comparative Data, 1992/93 – 1995/96.

[22] The size groups are defined in Chapter 6 of this thesis.

Table 4.3 shows that the total number of hospitals has decreased over the period from 117 to 101. The reduction in the number of hospitals shown is due to both hospital closures and amalgamations. Appendix IV shows that Local hospitals (Group ‘E’) experienced the greatest number of closures of 5 hospitals over the period, and also the greatest number of amalgamations of 7 hospitals. Thus, in the final year this group contains 12 hospitals less than it did in the first year.

The data for each characteristic taken from Appendix IV is also summarised. Table 4.4 sets out totals for each of the outputs and inputs by group over the period. Table 4.4 shows that total WIES declined in the second year of observation and then increased to 750,528. The total number of inpatients treated, however, rose over the period from 690,461 to 871,725. This was at the same time that EFT staff fell dramatically in the second year from 37,962 to 33,725 and then rose again to 36,095. The figures for total average available beds are similar in that they fell dramatically in the second year from 11,094 to 10,849, but rose again to 11,026 in the final year.

Table 4.4: Summary of Victorian Hospital Data 1992/93 – 1995/96

Group	Characteristic	1992/93	1993/94	1994/95	1995/96	Total
A	WIES	460226	456012	504845	502109	**1923192**
	Inpatients Treated	430655	461581	522099	557691	**1972026**
	EFT Staff (non-medical)	23594	21367	21975	23306	**90242**
	Average Available Beds	6207	6289	6400	6652	**25548**
B	WIES	173568	169473	178045	184989	**706075**
	Inpatients Treated	183860	195231	208134	227297	**814522**
	EFT Staff (non-medical)	9672	8190	7997	8848	**34707**
	Average Available Beds	3084	2892	2732	2860	**11568**
C	WIES	45019	40751	42401	42167	**170038**
	Inpatients Treated	49361	51294	54234	59664	**214553**
	EFT Staff (non-medical)	2526	2266	2282	2311	**9385**
	Average Available Beds	974	879	907	883	**3643**
D	WIES	23396	15594	15097	14983	**69025**
	Inpatients Treated	17457	18940	18259	19603	**74259**
	EFT Staff (non-medical)	1081	963	896	917	**3857**
	Average Available Beds	481	428	428	416	**1753**
E	WIES	14333	8768	7528	6280	**36909**
	Inpatients Treated	9128	9123	8242	7470	**33963**
	EFT Staff (non-medical)	1089	939	736	713	**3477**
	Average Available Beds	348	361	272	215	**1196**
Total	**WIES**	**716542**	**690553**	**747916**	**750528**	**2905539**
	Inpatients Treated	**690461**	**736169**	**810968**	**871725**	**3109323**
	EFT Staff (non-medical)	**37962**	**33725**	**33886**	**36095**	**141668**
	Average Available Beds	**11094**	**10849**	**10739**	**11026**	**43708**

Source: Victorian Hospital Comparative Data, 1992/93 – 1995/96

Table 4.4 also shows the differences in characteristics experienced by each of the groups. Whereas the WIES figure rose for Groups A and B over the period, it fell for the remaining smaller hospital groups. Inpatients treated rose for all groups with the exception of Group E hospitals, for which the figure fell. The number of EFT non-medical staff fell for all groups, whilst average available beds rose for Group A hospitals and fell for all others. Viewing these characteristics in terms of inputs and outputs[23], it is apparent that for Group A hospitals both outputs rose in quantity, with one input falling and the other one rising. For group B hospitals the outputs rose and the inputs fell. For group C hospitals one output rose and one fell, with both inputs falling. Group D experienced one output that rose and one that fell, with both inputs falling. Group E hospitals experienced reductions in both outputs and both inputs.

Table 4.5 and Table 4.5a show the provision and utilisation of hospitals in Australia at the end of the period under investigation, with a relative percentage for the other States and Territories relative to Victoria. Table 4.5 is reproduced from Duckett, 1999 and shows public acute general hospitals, private acute general hospitals, their number and utilisation. Table 4.5a has been constructed to show how, following the initial budget cuts and introduction of casemix funding in Victoria, Victorian hospitals compared to the other States and Territories that had not experienced health reform to the same extent. The highlighted rows in Table 4.5a show beds per 1000 population for public, private and total acute hospitals. Clearly, on average all other States and Territories have a higher ratio for this category then does Victoria (with some minor exceptions). The figures for South Australia show significantly higher ratios of 29, 11 and 23 percent above Victorian ratios respectively. Utilisation figures for South Australia are also considerably higher than Victoria's at this point in time.

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[23] WIES and Inpatients Treated = outputs; EFT staff and Average Available Beds = inputs.

Table 4.5: Provision and Utilisation of Hospitals, 1995/96

	NSW	VIC	QLD	WA	SA	TAS	ACT	NT	TOTAL
Provision									
Public acute general									
Number	218	138	192	98	82	20	3	5	756
Beds	21560	13139	11113	5547	5543	1468	780	570	59720
Beds/1000 pop.	3.50	2.91	3.35	3.18	3.76	3.10	2.56	3.22	3.29
Beds/hospital	98.90	95.21	57.88	56.60	67.60	73.40	260.00	114.00	78.99
Private acute general									
Number	169	134	63	47	30	10			453
Beds	6806	6241	4890	2438	2274	660			23309
Beds/1000 pop.	1.11	1.38	1.47	1.40	1.54	1.39			1.28
Beds/hospital	40.27	46.57	77.62	51.87	75.80	66.00			51.45
Total acute general									
Number	387	272	255	145	112	30			1209
Beds	28366	19380	16003	7985	7817	2128			83029
Beds/1000 pop.	4.61	4.29	4.83	4.57	5.30	4.50			4.57
Beds/hospital	73.30	71.25	62.76	55.07	69.79	70.93			68.68
Utilisation									
Public acute general									
Separations/1000 pop.	202.7	191.8	190.6	190.5	216.5	152.1	186.4	260.1	196.7
Bed days/1000 pop.	1058.8	809.5	835.1	769.9	920.5	802.3	760.9	1050.9	905.2
Private acute general									
Separations/1000 pop.	78.9	93.6	105.5	65.3	94.1	111.6	45.3		87.7
Bed days/1000 pop.	253.5	355.0	455.3	248.5	374.1	395.9	155.3		327.7
Total acute general									
Separations/1000 pop.	281.6	285.4	296.1	255.8	310.6	263.7	231.7	260.1	284.4
Bed days/1000 pop.	1312.3	1164.5	1290.4	1018.4	1294.6	1198.2	916.2	1050.9	1232.9

Source: Reproduced from Duckett (1999), Table 5.1
Original Source: Australian Institute of Health and Welfare, *Australian Hospital Statistics, 1995/96*, tables 2.2 and 3.2; and AIHW periodical communications.
Original Note: ACT and NT private hospital data are included in NSW and SA respectively.

Table 4.5(a): States and Territories % change relative to Victoria, Table 4.5, 1995/96

	% NSW	% QLD	% WA	% SA	% TAS	% ACT	% NT	% AVG. TOTAL
Provision								
Public acute general								
Number	+58.0	+39.1	-29	-40.5	-85.5	-97.8	-96.4	
Beds	+64.1	-15.4	-57.7	-57.8	-88.8	-94.1	-95.7	
Beds/1000 pop.	+20.3	+15.1	+9.3	+29.2	+6.5	-12.0	+10.6	+13.0
Beds/hospital	+3.9	-39.2	-40.5	-29.0	-22.9	+173	+19.7	-17.0
Private acute general								
Number	+26.1	-53.0	-65.0	-77.6	-92.5			
Beds	+9.0	-21.4	-60.9	-63.5	-89.4			
Beds/1000 pop.	-19.5	+6.5	+1.4	+11.6	+0.7			-7.2
Beds/hospital	-13.5	+66.7	+11.4	+62.7	+41.7			+10.5
Total acute general								
Number	+42.3	-6.2	-46.7	-58.8	-88.9			
Beds	+46.3	-17.4	-58.8	-59.6	-89.0			
Beds/1000 pop.	+7.4	+12.6	+6.5	+23.5	+4.9			+6.5
Beds/hospital	+2.8	-11.9	-22.7	-2.0	-0.4			-3.6
Utilisation								
Public acute general								
Separations/1000 pop.	+5.6	-0.6	-0.6	+12.8	-20.7	-2.8	+35.6	+2.5
Bed days/1000 pop.	+30.8	+3.1	-4.9	+13.7	-0.8	-6.0	+29.8	+11.8
Private acute general								
Separations/1000 pop.	-15.7	+12.7	-30.2	+0.5	+19.2	-51.6		-6.3
Bed days/1000 pop.	-28.6	+28.2	-30.0	+5.4	+11.5	-56.2		-7.7
Total acute general								
Separations/1000 pop.	-1.3	+3.7	-10.3	+8.8	-7.6	-18.8	-8.8	-0.3
Bed days/1000 pop.	+12.7	+10.8	-12.5	+11.1	+2.9	-21.3	-9.7	+5.8

Source: Constructed from Table 4.5.

4.12 Discussion

This chapter has provided a background to health reform and the implementation of casemix funding in Victoria within the context of the Australian healthcare system. The pressures for reform of Victoria's acute hospitals stemmed from excessive State debt as well as an identified need to improve hospital funding efficiency, together with the issue of conforming to the new competition policy legislation. Given the obvious increase in the rate of growth of health expenditure in Victoria since 1995/96 (Graph 4.1) it is difficult to reconcile this with the initial objectives for adopting casemix funding.

Also, the existence of budget caps directly opposes the incentives in place for hospitals to meet waiting list targets. This may blunt hospitals' inclination to increase throughput indefinitely since a reduction in waiting lists would entail overrunning their annual budget. As no budget overruns will be funded under the current system, it becomes necessary for hospitals to allow waiting lists to grow; another contradiction of the initial objectives for adopting casemix funding. The growing number of Category Three patients provides evidence that this is occurring. On the face of it, this combination of incentives appears to be directed at hospitals to better manage their limited resources. However, the budget cap applies to a given number of WIES annually which have already been weighted for resource utilisation. Furthermore, the figures in Tables 4.5 and 4.5a indicate that relative to other States, Victoria provided less public hospital beds per 1000 population (with the exception of the ACT) immediately following the period under consideration. These figures also point to the fact that waiting lists grew in Victoria, although the evidence in these tables is not overwhelming since data provided is for one year only.

APPENDIX IV

Tables of Raw Data for 4 Characteristics

for Hospitals by Group

Victoria 1992/93 to 1995/96

Group A Hospitals – Summary Data Table 1992/93-1995/96

Hospital	Characteristic	1992/93	1993/94	1994/95	1995/96
Alfred	WIES	50942	53890	56183	55243
	Inpatients Treated	37234	44360	53914	53964
	EFT Staff (non-medical staff)	3051	2845	2844	2937
	Average Available Beds	637	710	666	682
Austin	WIES	39234	36650	60101	53692
	Inpatients Treated	35218	32889	56413	54680
	EFT Staff (non-medical staff)	1920	1754	2518	3019
	Average Available Beds	564	504	865	776
Box Hill	WIES	20441	20562	21684	22143
	Inpatients Treated	19251	21279	23229	25384
	EFT Staff (non-medical staff)	861	818	812	823
	Average Available Beds	312	275	254	262
Cancer Institute	WIES	8935	9223	10576	11313
	Inpatients Treated	9108	8472	9011	8952
	EFT Staff (non-medical staff)	921	839	797	780
	Average Available Beds	132	133	135	136
Dandenong	WIES	21974	22217	22828	21447
	Inpatients Treated	21065	23347	21918	23799
	EFT Staff (non-medical staff)	1046	1004	1043	1010
	Average Available Beds	256	290	279	335
Geelong	WIES	29987	28929	30449	31201
	Inpatients Treated	27653	29936	32460	34737
	EFT Staff (non-medical staff)	1370	1248	1284	1308
	Average Available Beds	400	398	417	427
Mercy Womens (includes Werribee in 94/95 - 95/96)	WIES	14519	14301	19564	21023
	Inpatients Treated	12142	13444	20748	27460
	EFT Staff (non-medical staff)	726	671	737	762
	Average Available Beds	236	306	300	309
Monash M.C.	WIES	47714	42548	47657	49309
	Inpatients Treated	46330	45053	52000	58181
	EFT Staff (non-medical staff)	2428	1922	2022	2163
	Average Available Beds	699	542	550	594
Mornington	WIES	26507	25204	25248	28661
	Inpatients Treated	26066	27763	27552	34409
	EFT Staff (non-medical staff)	1086	985	959	1161
	Average Available Beds	300	345	326	433
P.A.N.C.H.	WIES	19124	18856	19416	20263
	Inpatients Treated	19005	19793	20051	21718
	EFT Staff (non-medical staff)	888	797	786	947
	Average Available Beds	257	282	277	324
Royal Children	WIES	27431	26025	26567	26981
	Inpatients Treated	25203	25388	26753	27810
	EFT Staff (non-medical staff)	1474	1411	1388	1382
	Average Available Beds	314	327	310	322
Royal Melbourne	WIES	51778	56587	59622	53582
	Inpatients Treated	51000	59298	63003	56862
	EFT Staff (non-medical staff)	2628	2445	2452	2628
	Average Available Beds	633	657	613	634
Royal Victorian Eye and Ear	WIES	8168	7314	7754	8390
	Inpatients Treated	11527	11680	11679	12645
	EFT Staff (non-medical staff)	425	392	392	359
	Average Available Beds	96	115	97	92
Royal Women’s	WIES	24195	24427	25552	24182
	Inpatients Treated	28403	31959	33951	37812
	EFT Staff (non-medical staff)	1290	1072	1063	1014
	Average Available Beds	430	504	386	386
St Vincents	WIES	35701	36943	36056	37600
	Inpatients Treated	29723	32530	32360	35762
	EFT Staff (non-medical staff)	1881	1732	1501	1603
	Average Available Beds	465	467	424	421
Western	WIES	33576	32336	35588	37079
	Inpatients Treated	31727	34390	37057	43516
	EFT Staff (non-medical staff)	1599	1432	1377	1410
	Average Available Beds	476	434	501	519

Group B Hospitals – Summary Data Table 1992/93-1995/96

Hospital	Characteristic	1992/93	1993/94	1994/95	1995/96
Ballarat Base	WIES	14622	14707	16490	16681
	Inpatients Treated	16164	16694	18444	19842
	EFT Staff (non-medical staff)	740	706	666	610
	Average Available Beds	217	225	211	210
Bendigo Base	WIES	12975	12941	13949	16736
	Inpatients Treated	13537	14741	16323	18948
	EFT Staff (non-medical staff)	600	487	510	1149
	Average Available Beds	229	201	181	309
Bairnsdale (East Gippsland. No data for 93/94)	WIES	4263		4608	4625
	Inpatients Treated	4203		4611	5011
	EFT Staff (non-medical staff)	423		358	355
	Average Available Beds	192		111	106
Echuca	WIES	3929	3766	4043	4143
	Inpatients Treated	4723	4671	5173	5790
	EFT Staff (non-medical staff)	271	244	245	253
	Average Available Beds	74	56	57	55
Fairfield (Group A from 93/94 onwards)	WIES	11610	6692	8101	11267
	Inpatients Treated	10865	11139	12285	12591
	EFT Staff (non-medical staff)	533	456	426	367
	Average Available Beds	137	134	134	134
Gippsland Base (closure)	WIES	6390	6199		
	Inpatients Treated	6105	6921		
	EFT Staff (non-medical staff)	356	317		
	Average Available Beds	102	109		
Goulburn Valley (Tatura)	WIES	10511	11686	11930	12477
	Inpatients Treated	11322	12146	12733	14052
	EFT Staff (non-medical staff)	613	582	569	609
	Average Available Beds	216	242	242	205
Hamilton Base	WIES	4583	4959	5105	4336
	Inpatients Treated	5097	5481	5697	5274
	EFT Staff Number (non-medical staff)	352	323	301	272
	Average Available Beds	94	98	92	77
La Trobe Regional	WIES	13355	13341	14358	15889
	Inpatients Treated	13788	15476	18130	20691
	EFT Staff (non-medical staff)	821	684	591	789
	Average Available Beds	236	184	184	204
Maroondah	WIES	13538	13782	14587	14647
	Inpatients Treated	11507	13692	15248	15416
	EFT Staff (non-medical staff)	562	606	598	657
	Average Available Beds	174	197	192	211
Mildura Base	WIES	11813	10524	10925	10647
	Inpatients Treated	13561	13029	13655	14618
	EFT Staff (non-medical staff)	705	440	539	534
	Average Available Beds	179	160	152	154
Mordialloc (includes Cheltenham from 94/95 onwards)	WIES	3425	2856	3084	3218
	Inpatients Treated	4263	3890	4177	4898
	EFT Staff (non-medical staff)	102	101	100	93
	Average Available Beds	68	68	68	68
Sandringham	WIES	5550	5186	5444	5714
	Inpatients Treated	5229	5682	6138	6957
	EFT Staff (non-medical staff)	203	196	192	181
	Average Available Beds	92	93	70	70
St Georges Inner East	WIES	6697	9814	10493	9875
	Inpatients Treated	8899	9269	9279	9810
	EFT Staff (non-medical staff)	533	472	444	465
	Average Available Beds	243	222	221	216
Swan Hill	WIES	3575	3590	3666	3540
	Inpatients Treated	4364	4647	4951	5074
	EFT Staff (non-medical staff)	243	219	204	209
	Average Available Beds	84	80	80	80
The Angliss	WIES	9625	9220	9937	9317
	Inpatients Treated	10171	10472	11671	13639
	EFT Staff (non-medical staff)	365	331	310	307
	Average Available Beds	150	185	125	106

Group B Hospitals continued.

Hospital	Characteristic	1992/93	1993/94	1994/95	1995/96
Wangaratta Base	WIES	8362	9032	8775	8899
	Inpatients Treated	8504	9654	9801	10323
	EFT Staff (non-medical staff)	466	413	389	422
	Average Available Beds	140	140	136	166
Warrnambool	WIES	8230	9039	9755	9548
	Inpatients Treated	9734	10916	11618	12104
	EFT Staff (non-medical staff)	591	600	548	489
	Average Available Beds	124	154	155	151
West Gippsland (Warragul)	WIES	5377	5711	6260	6212
	Inpatients Treated	5375	7116	8378	9706
	EFT Staff (non-medical staff)	316	289	284	283
	Average Available Beds	84	86	83	83
Williamstown	WIES	5174	6363	5686	5521
	Inpatients Treated	5404	6960	5958	6379
	EFT Staff (non-medical staff)	257	234	185	212
	Average Available Beds	92	98	82	79
Wimmera Base	WIES	4988	4608	4922	5424
	Inpatients Treated	5096	5732	5972	6884
	EFT Staff (non-medical staff)	393	331	321	349
	Average Available Beds	80	71	71	89
Wodonga	WIES	4976	5457	5927	6273
	Inpatients Treated	5949	6903	7892	9290
	EFT Staff (non-medical staff)	227	159	217	243
	Average Available Beds	77	89	85	87

Group C Hospitals – Summary Data Table 1992/93-1995/96

Hospital	Characteristic	1992/93	1993/94	1994/95	1995/96
Altona	WIES	1118	1532	959	643
	Inpatients Treated	1247	1913	1219	1003
	EFT Staff (non-medical staff)	35	32	26	19
	Average Available Beds	25	25	25	13
Ararat (includes Willaura and East Grampians from 94/95 onwards)	WIES	2366	2402	2571	2481
	Inpatients Treated	2865	2872	2943	3201
	EFT Staff (non-medical staff)	168	156	162	162
	Average Available Beds	65	45	53	53
Bacchus Marsh	WIES	2101	2140	2273	2175
	Inpatients Treated	2703	3040	3288	3326
	EFT Staff (non-medical staff)	82	76	79	77
	Average Available Beds	41	41	41	41
Benalla	WIES	2883	2915	2699	2913
	Inpatients Treated	2960	3434	3275	3568
	EFT Staff (non-medical staff)	176	154	144	145
	Average Available Beds	60	45	45	45
Burwood	WIES	1648	1385	1483	1565
	Inpatients Treated	1938	2313	2813	3997
	EFT Staff (non-medical staff)	28	30	30	30
	Average Available Beds	15	18	18	18
Camperdown (includes LSM, Corangamite from 94/95 onwards)	WIES	1082	1082	1309	1255
	Inpatients Treated	1186	1336	1434	1500
	EFT Staff (non-medical staff)	76	67	68	71
	Average Available Beds	31	27	33	28
Cobram District	WIES	1093	1214	1184	1076
	Inpatients Treated	1357	1679	1541	1453
	EFT Staff (non-medical staff)	63	57	54	56
	Average Available Beds	30	30	30	30
Cohuna	WIES	1071	945	998	927
	Inpatients Treated	1154	1074	1279	1300
	EFT Staff (non-medical staff)	49	50	50	49
	Average Available Beds	22	20	22	21
Colac	WIES	3332	2931	3110	3092
	Inpatients Treated	3256	3381	3625	3856
	EFT Staff (non-medical staff)	223	214	211	229
	Average Available Beds	65	65	65	65
Healesville (includes Yarra Ranges in 95/96)	WIES	1009	911	1092	1058
	Inpatients Treated	1234	1197	1475	1542
	EFT Staff (non-medical staff)	33	33	38	43
	Average Available Beds	21	21	21	21
Kerang	WIES	1554	1287	1125	1172
	Inpatients Treated	1528	1541	1369	1587
	EFT Staff (non-medical staff)	85	77	71	71
	Average Available Beds	32	32	26	24
Gippsland South (Korumburra)	WIES	2337	2294	2517	2508
	Inpatients Treated	2455	3191	3618	3841
	EFT Staff (non-medical staff)	199	167	174	173
	Average Available Beds	72	45	47	45
Kyabram	WIES	2296	2191	2364	2430
	Inpatients Treated	2776	2983	3518	4200
	EFT Staff (non-medical staff)	109	105	106	108
	Average Available Beds	46	46	46	49
Kyneton	WIES	1086	1354	1317	1323
	Inpatients Treated	1302	1705	1824	1927
	EFT Staff (non-medical staff)	71	60	62	62
	Average Available Beds	39	39	34	33
Mansfield	WIES	1080	1114	1176	1237
	Inpatients Treated	1483	1563	1925	1964
	EFT Staff (non-medical staff)	58	53	53	55
	Average Available Beds	28	28	28	28
Maryborough	WIES	2577	2507	2366	2469
	Inpatients Treated	2579	2865	2694	3019
	EFT Staff (non-medical staff)	179	167	161	165
	Average Available Beds	56	56	47	55

Group C Hospitals continued.

Hospital	Characteristic	1992/93	1993/94	1994/95	1995/96
Nhill (includes West Wimmera HS from 94/95 onwards)	WIES	1954	1082	1590	1473
	Inpatients Treated	1091	1190	1587	1626
	EFT Staff (non-medical staff)	107	107	144	139
	Average Available Beds	40	35	48	50
Numurkah	WIES	1352	1081	1225	1258
	Inpatients Treated	1387	1452	1421	1592
	EFT Staff (non-medical staff)	82	73	74	75
	Average Available Beds	33	33	33	33
Portland	WIES	2799	3099	3208	3415
	Inpatients Treated	3131	3683	3846	4587
	EFT Staff (non-medical staff)	160	155	149	150
	Average Available Beds	55	55	64	65
Seymour	WIES	1602	1256	1442	1604
	Inpatients Treated	1720	1722	2061	2692
	EFT Staff (non-medical staff)	81	78	78	79
	Average Available Beds	33	34	33	33
Stawell	WIES	2012	2005	2150	2049
	Inpatients Treated	2125	2153	2326	2357
	EFT Staff (non-medical staff)	119	115	112	116
	Average Available Beds	40	40	49	40
Werribee (amalgamated with Mercy Womens)	WIES	2326	n/a		
	Inpatients Treated	2957	n/a		
	EFT Staff (non-medical staff)	93	n/a		
	Average Available Beds	32	n/a		
Wonthaggi	WIES	2990	2684	2805	2779
	Inpatients Treated	3236	3130	3145	3440
	EFT Staff (non-medical staff)	165	159	158	161
	Average Available Beds	60	60	60	60
Yarrawonga	WIES	1351	1340	1438	1265
	Inpatients Treated	1691	1877	2008	2086
	EFT Staff (non-medical staff)	85	81	78	76
	Average Available Beds	33	39	39	33

Group D Hospitals – Summary Data Table 1992/93-1995/96

Hospital	Characteristic	1992/93	1993/94	1994/95	1995/96
Alexandra	WIES	1230	982	1110	1031
	Inpatients Treated	1215	1345	1690	1443
	EFT Staff (non-medical staff)	46	40	38	38
	Average Available Beds	30	30	30	30
Coleraine	WIES	396	484	510	419
	Inpatients Treated	452	536	564	476
	EFT Staff (non-medical staff)	34	30	30	30
	Average Available Beds	15	15	15	15
Corryong (closure)	WIES	721	554		
	Inpatients Treated	696	689		
	EFT Staff (non-medical staff)	55	50		
	Average Available Beds	18	18		
Daylesford (includes Creswick and Western Highlands from 94/95)	WIES	781	702	990	1092
	Inpatients Treated	732	734	1030	1243
	EFT Staff (non-medical staff)	44	42	77	77
	Average Available Beds	20	20	30	30
Edenhope District	WIES	895	711	670	694
	Inpatients Treated	642	785	655	699
	EFT Staff (non-medical staff)	47	42	40	41
	Average Available Beds	20	20	20	20
Kilmore	WIES	1035	968	1040	1185
	Inpatients Treated	1165	1306	1444	1926
	EFT Staff (non-medical staff)	30	31	32	35
	Average Available Beds	20	20	20	30
Maffra	WIES	991	792	864	748
	Inpatients Treated	936	1018	1131	1205
	EFT Staff (non-medical staff)	57	56	55	58
	Average Available Beds	15	15	19	15
Myrtleford	WIES	922	907	943	858
	Inpatients Treated	994	1223	1124	1180
	EFT Staff (non-medical staff)	64	53	57	58
	Average Available Beds	23	23	23	23
Orbost (closure)	WIES	873	621		
	Inpatients Treated	684	708		
	EFT Staff (non-medical staff)	37	36		
	Average Available Beds	26	15		
Ouyen	WIES	731	417	460	401
	Inpatients Treated	488	430	436	457
	EFT Staff (non-medical staff)	67	55	55	53
	Average Available Beds	22	15	15	15
Port Fairy	WIES	957	565	529	490
	Inpatients Treated	445	550	510	541
	EFT Staff (non-medical staff)	48	43	42	40
	Average Available Beds	41	14	16	20
Rochester (Elmore)	WIES	1087	944	901	916
	Inpatients Treated	1113	1221	1225	1291
	EFT Staff (non-medical staff)	67	62	59	59
	Average Available Beds	24	24	33	24
Skipton District	WIES	380	369	377	282
	Inpatients Treated	341	355	340	264
	EFT Staff (non-medical staff)	16	14	15	18
	Average Available Beds	10	10	10	10
South Gippsland	WIES	868	916	930	957
	Inpatients Treated	900	1019	1057	1152
	EFT Staff (non-medical staff)	23	25	26	26
	Average Available Beds	16	16	16	16
St Arnaud	WIES	688	560	545	549
	Inpatients Treated	663	662	601	621
	EFT Staff (non-medical staff)	72	56	49	51
	Average Available Beds	20	20	20	20
Tawonga District	WIES	665	644	614	590
	Inpatients Treated	816	855	829	796
	EFT Staff (non-medical staff)	39	39	40	43
	Average Available Beds	15	15	15	15

Group D Hospitals continued.

Hospital	Characteristic	1992/93	1993/94	1994/95	1995/96
Terang District (includes Mortlake from 94/95 onwards)	WIES	1231	971	1173	1112
	Inpatients Treated	1079	1313	1400	1496
	EFT Staff (non-medical staff)	57	55	55	62
	Average Available Beds	27	27	39	27
Timboon District	WIES	779	620	702	726
	Inpatients Treated	959	817	943	985
	EFT Staff (non-medical staff)	26	25	29	31
	Average Available Beds	20	20	20	19
Warracknabeal	WIES	3157	663	576	679
	Inpatients Treated	711	740	559	726
	EFT Staff (non-medical staff)	127	99	88	79
	Average Available Beds	49	40	36	35
Westernport	WIES	1227	1136	1182	1180
	Inpatients Treated	1433	1560	1706	1778
	EFT Staff (non-medical staff)	47	42	42	45
	Average Available Beds	21	20	20	21
Yarram	WIES	3224	561	549	530
	Inpatients Treated	464	558	529	749
	EFT Staff (non-medical staff)	49	42	42	47
	Average Available Beds	16	18	18	18
Yea	WIES	558	462	432	544
	Inpatients Treated	529	516	486	575
	EFT Staff (non-medical staff)	29	26	25	26
	Average Available Beds	13	13	13	13

Group E Hospitals – Summary Data Table 1992/93-1995/96

Hospital	Characteristic	1992/93	1993/94	1994/95	1995/96
Apollo Bay (closure)	WIES	446	282		
	Inpatients Treated	275	283		
	EFT Staff (non-medical staff)	21	18		
	Average Available Beds	12	12		
Birregurra	WIES	761	164	130	90
	Inpatients Treated	167	193	145	94
	EFT Staff (non-medical staff)	12	12	11	11
	Average Available Beds	6	6	6	6
Boort	WIES	525	371	388	381
	Inpatients Treated	421	424	465	540
	EFT Staff (non-medical staff)	28	27	29	30
	Average Available Beds	9	9	9	9
Bright	WIES	503	528	605	523
	Inpatients Treated	486	640	784	711
	EFT Staff (non-medical staff)	21	27	29	33
	Average Available Beds	9	9	9	9
Casterton	WIES	912	530	577	585
	Inpatients Treated	615	619	826	942
	EFT Staff (non-medical staff)	55	52	52	53
	Average Available Beds	18	18	18	18
Clunes (closure)	WIES	133	108		
	Inpatients Treated	101	93		
	EFT Staff (non-medical staff)	21	17		
	Average Available Beds	4	4		
Creswick (amalgamated with Daylesford)	WIES	575	337		
	Inpatients Treated	419	334		
	EFT Staff (non-medical staff)	22	31		
	Average Available Beds	10	10		
Dimboola (amalgamated with Wimmera)	WIES	1430	447	439	
	Inpatients Treated	561	529	543	
	EFT Staff (non-medical staff)	53	48	44	
	Average Available Beds	18	18	18	
Donald	WIES	594	348	459	485
	Inpatients Treated	432	416	614	573
	EFT Staff (non-medical staff)	35	29	26	26
	Average Available Beds	20	18	18	18
Dunmunkle	WIES	502	228	117	39
	Inpatients Treated	195	195	84	32
	EFT Staff (non-medical staff)	49	42	30	32
	Average Available Beds	11	12	4	4
Eildon (closure)	WIES	132			
	Inpatients Treated	71			
	EFT Staff (non-medical staff)	8			
	Average Available Beds	5			
Heathcote (renamed McIvor in 94/95)	WIES	288	350	323	311
	Inpatients Treated	319	369	310	389
	EFT Staff (non-medical staff)	23	22	23	27
	Average Available Beds	7	7	7	7
Heywood	WIES	516	235	287	252
	Inpatients Treated	261	197	263	196
	EFT Staff (non-medical staff)	28	29	34	40
	Average Available Beds	12	12	11	11
Inglewood	WIES	228	259	277	281
	Inpatients Treated	238	231	260	285
	EFT Staff (non-medical staff)	22	24	29	30
	Average Available Beds	10	10	10	10
Jeparit (amalgamated with Nhill, Kaniva – West Wimmera)	WIES	n/a	118		
	Inpatients Treated	n/a	107		
	EFT Staff (non-medical staff)	n/a	19		
	Average Available Beds	n/a	4		
Kaniva (amalgamated with Nhill, Jeparit – West Wimmera)	WIES	355	207		
	Inpatients Treated	191	171		
	EFT Staff (non-medical staff)	32	27		
	Average Available Beds	10	21		
Koroit (closure)	WIES	434	14		
	Inpatients Treated	112	112		
	EFT Staff (non-medical staff)	33	22		
	Average Available Beds	7	7		

Group E Hospitals continued.

Hospital	Characteristic	1992/93	1993/94	1994/95	1995/96
Lismore (amalgamated with Camperdown – Corangamite)	WIES	202	86		
	Inpatients Treated	111	75		
	EFT Staff (non-medical staff)	18	17		
	Average Available Beds	6	12		
Lorne	WIES	358	352	436	375
	Inpatients Treated	397	437	537	480
	EFT Staff (non-medical staff)	24	25	24	26
	Average Available Beds	8	8	8	8
MacArthur (closure)	WIES	76			
	Inpatients Treated	104			
	EFT Staff (non-medical staff)	13			
	Average Available Beds	4			
Maldon	WIES	158	147	154	136
	Inpatients Treated	122	145	165	126
	EFT Staff (non-medical staff)	22	21	26	31
	Average Available Beds	8	8	8	8
Manangatang	WIES	149	81	136	147
	Inpatients Treated	123	50	130	170
	EFT Staff (non-medical staff)	22	18	18	17
	Average Available Beds	6	6	6	6
Mortlake (amalgamated with Terang)	WIES	291	201		
	Inpatients Treated	262	204		
	EFT Staff (non-medical staff)	20	15		
	Average Available Beds	12	12		
Nathalia	WIES	324	382	348	288
	Inpatients Treated	382	401	353	307
	EFT Staff (non-medical staff)	22	21	22	21
	Average Available Beds	10	10	10	10
Omeo	WIES	109	85	133	123
	Inpatients Treated	120	118	143	150
	EFT Staff (non-medical staff)	18	18	19	18
	Average Available Beds	3	4	4	4
Beechworth (Ovens)	WIES	1252	881	1017	540
	Inpatients Treated	718	759	901	687
	EFT Staff (non-medical staff)	294	180	156	147
	Average Available Beds	48	48	48	23
Penshurst	WIES	211	274	211	167
	Inpatients Treated	165	233	171	140
	EFT Staff (non-medical staff)	19	18	18	19
	Average Available Beds	7	8	7	7
Ripon Peace	WIES	537	302	418	431
	Inpatients Treated	294	257	405	401
	EFT Staff (non-medical staff)	21	24	29	31
	Average Available Beds	15	10	10	11
Tallangatta	WIES	489	357	360	361
	Inpatients Treated	383	445	377	357
	EFT Staff (non-medical staff)	33	31	29	30
	Average Available Beds	15	20	20	20
Waranga	WIES	554	389	208	182
	Inpatients Treated	422	357	186	193
	EFT Staff (non-medical staff)	22	21	21	22
	Average Available Beds	12	12	12	8
Willaura (amalgamated with Ararat – East Grampians)	WIES	602	138		
	Inpatients Treated	62	84		
	EFT Staff (non-medical staff)	19	15		
	Average Available Beds	8	8		
Winchelsea	WIES	403	360	299	308
	Inpatients Treated	373	403	339	382
	EFT Staff (non-medical staff)	19	34	33	33
	Average Available Beds	8	8	19	8
Wycheproof	WIES	284	207	206	275
	Inpatients Treated	226	242	241	315
	EFT Staff (non-medical staff)	40	35	34	36
	Average Available Beds	10	10	10	10

Source: Victorian Hospital Comparative Data 1992/93-1995/96

Chapter 5

Examination of Economies of Scale in Victorian Hospitals

5.1 Overview

The central thesis of this chapter is to apply survivor analysis, the background of which is discussed in Chapter 3, to determine the minimum efficient scale for both private and public hospitals in the State of Victoria over the period 1991/92 to 1995/96. Survivor analysis was first proposed by Mill (1909) and later developed by Stigler (1958). In his paper, Stigler (1958) states that the use of survivor analysis is favourable because it avoids the problems associated with historical cost valuations and with, what he terms, the ‘hypothetical’ nature of technological studies. The basic postulate of survivor analysis is that by viewing competition between different sized firms, we can determine what is the optimal size range and which firms are, therefore, more efficient.

A study by Frech and Mobley (1995), which applies this technique to US data, concludes that scale economies exist in the US hospital sector. They find that the market share of small hospitals falls and that of large hospitals increases over time due to the competitive nature of the market. The results support the view that health provision by smaller hospitals may be of an inferior quality and, therefore, the reduction in their market share is reflective of inefficiencies.

Economies of scale exist when, as the size of a plant increases, long-run average total costs fall. Thus, the long-run average total cost curve is ‘U’ shaped, making the ideal plant size positioned at its minimum point, or minimum efficient scale. Reductions in average costs of production can be achieved for the following reasons:

- Labour specialisation;
- Managerial specialisation;
- Efficient capital; and,
- By-products

As the size of plant increases, workers can specialise in fewer tasks, making them more efficient. Labour specialisation also allows skilled workers to leave more mundane tasks to unskilled workers (Jackson and McIver, 2004).

The application of managerial skills to a large production process is less costly per unit of output than it is for small processes. Supervising a small number of personnel represents underuse of managerial resources. Also, in the same vein as labour specialisation, managerial specialisation lowers unit costs because managers are responsible for supervising a particular area, for example nursing staff (Jackson and McIver, 2004).

Capital equipment is costly, and therefore efficiencies exist for large-scale producers, since effective use of capital demands a high volume of production. Small-scale producers often do not generate sufficient output to justify the purchase of costly capital equipment. Also, the production of by-products assists large-scale producers in that, due to the fact that they are in large quantities, producers are able to sell them to other firms. Small-scale producers, however, are less likely to use their by-products; leading to wastage.

It is also possible for diseconomies of scale to exist. In the case where an increase in firm size leads to an increase in bureaucratic red tape that inhibits communication flows, average total costs could rise. This scenario is represented by a position to the right of minimum costs on the ‘U’ shaped long-run average cost curve (Jackson and McIver, 2004).

In this analysis, hospitals are grouped into size according to average available beds, and total output is measured using average bed days. The data for this analysis has been gathered from the Department of Human Services, Victoria (special request), the Australian Bureau of Statistics, and the Victorian Hospital Comparative Data set. The period under consideration is chosen because the changeover to casemix funding on 1 July 1993 signalled an increase in competition for government funding between public hospitals. This is supported by the Victorian Department of Human Services’ outline of casemix funding and DRGs.

> The overall aim of casemix funding was to enhance and expand the hospital system in Victoria through a process that was free from centralised bureaucratic control, engendered competition and economic incentives for hospitals, and rewarded efficiency and growth in services while at the same time guarded quality.
> (Brook, 2006, p2)

A comparison with the private sector for survivor analysis shows whether there was any change in market share between private and public hospitals in Victoria.

5.2 Survivor Analysis

The following analysis is a description of the change in market shares of both public and private hospitals for Victoria and Australia. Data has been gathered for the years 1991/92 and 1995/96 for all hospitals with the exception of Australian public hospitals, which is data for 1993/94 and 1999/00. This minor discrepancy arises due to the limitation of data availability, but nevertheless allows us to view, to some extent, how Victorian public hospitals have compared with the Australian market as a whole. The analysis begins with three tables for Public Hospitals – Victoria (91/92 to 95/96).

Table 5.1 - Public Hospitals and Bed Days by Hospital Size – Victoria (91/92 to 95/96)

Average Available Beds (Hospital Size)	No. of Hospitals		Total Bed Days	
	91/92	95/96	91/92	95/96
0-49	77	61	363028	240310
50-199	25	25	586501	621929
200-399	11	12	823438	974777
400 +	8	8	1281891	1528947
Total	**121**	**106**[24]	**3054858**	**3365963**

Source: Victorian Hospitals Association, 91/92 and 95/96: Rainbow Hospital Indicators

Using the Total Bed Days columns of Table 5.1, it is possible to measure the rate of change of bed days between the two periods. Table 5.2 shows a clear reduction in bed days for the smallest hospital group with less than 50 average available beds, although total bed days have increased from 3,054,858 to 3,365,963 for the period.

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[24] The number of hospitals is more than the number reported at Appendix IV because 5 hospitals are omitted from Appendix IV due to the fact that their characteristic data was not consistent over the period.

Table 5.2 – Public Hospital Bed Days (Rate of Change)
– Victoria (91/92 to 95/96)

Average Available Beds	91/92	95/96	Change	Rate of Change
0-49	363028	240310	-337	-0.338
50-199	586501	621929	97	0.060
200-399	823438	974777	415	0.184
400 +	1281891	1528947	677	0.193
Total	**3054858**	**3365963**		

Source: Victorian Hospitals Association 91/92 and 95/96: Rainbow Hospital Indicators

Table 5.3 illustrates market share using the proportions of the total market obtained from Table 5.2.

Table 5.3 – Market share and rate of change – Public Hospital Bed Days
– Victoria (91/92 to 95/96)

Average Available Beds	91/92	95/96	Change	Rate of Change[25]
0-49	0.119	0.071	-0.048	-0.400
50-199	0.192	0.185	-0.007	-0.038
200-399	0.270	0.290	0.020	0.074
400 +	0.420	0.454	0.035	0.082
Total	**1.000**	**1.000**		

Source: Victorian Hospitals Association 91/92 and 95/96: Rainbow Hospital Indicators

In this group (Public hospitals – Victoria) the number of hospitals declined by 12 percent over the period, with bed days rising by 10 percent. From Table 5.2 it is clear that bed days fell by over 33 percent for the smallest hospital group (0-49 beds), and rose for all larger groups. Table 5.3 shows that market share of public hospital bed days fell for hospitals with up to 199 beds and rose for all larger groups. Of interest is the 50-199 beds group. Although this group experienced an increase in bed days, the increase was less than the increase of larger groupings, and thus its share of the market declined. In comparison, following are three tables for Private Hospitals – Victoria for the same period.

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[25] Using a Chi-squared test, the null hypothesis of no change is strongly rejected at the 1% level of significance.

Table 5.4 - Private Hospitals and Bed Days by Hospital Size[26] – Victoria (91/92 to 95/96)

Average Available Beds (Hospital Size)	No. of Hospitals		Total Bed Days	
	91/92	95/96	91/92	95/96
0-25	39	33	148700	112900
26-50	35	30	278600	255200
51-100	23	24	388200	437500
101-200	9	13	297100	477700
201+	5	4	365100	320600
Total	**111**	**104**	**1477700**	**1603900**

Source: Department of Human Services (special request)

The change in bed days for this group is shown in Table 5.5.

Table 5.5 –Private Hospital Bed Days (Rate of Change) – Victoria (91/92 to 95/96)

Average Available Beds	91/92	95/96	Change	Rate of Change
0-25	148700	112900	-98	-0.24
26-50	278600	255200	-64	-0.08
51-100	388200	437500	135	0.13
101-200	297100	477700	495	0.61
201 +	365100	320600	-122	-0.12
Total	**1477700**	**1603900**		

Source: Department of Human Services (special request)

Table 5.6 – Market share and rate of change –Private Hospital Bed Days – Victoria (91/92 to 95/96)

Average Available Beds	91/92	95/96	Change	Rate of Change
0-25	0.10	0.07	-0.03	-0.30
26-50	0.19	0.16	-0.03	-0.16
51-100	0.26	0.27	0.01	0.04
101-200	0.20	0.30	0.10	0.48
201 +	0.25	0.20	-0.05	-0.19
Total	**1.000**	**1.000**		

Source: Department of Human Services (special request)

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[26] Hospital size ranges differ from Public Hospitals Victoria because they are obtained from a different data source.

In this group the number of hospitals declined by 6 per cent over the period, with bed days rising by 8.5 percent. Table 5.5 shows that bed days fell by over 13 percent for the two smallest combined groups with 0-50 beds. Bed days also fell by 12 percent for the largest hospitals with over 201 beds. Table 5.6 shows that the market share of private hospital bed days fell for hospitals with up to 50 beds, rose for those with between 51 and 200 beds, and fell by 19 percent for the largest hospitals with over 200 beds. One explanation for this reduced market share within the largest group is that there was one fewer hospital at the end of the period in this group (refer to Table 5.4), resulting in fewer bed days.

It is apparent from the analysis that there has been a movement away from smaller hospitals in Victoria, evidenced by their decreasing market share. This is more apparent for Victorian public hospitals than for private hospitals, although both types experienced falling market share among hospitals with fewer than 50 beds. In both Victorian groups the number of hospitals declined due to closure, or amalgamations that resulted in a larger hospital. Amalgamation does not increase the number of hospitals in the larger groups, merely the number of bed days following amalgamation. This is because amalgamations occur between small hospitals and large hospitals. Furthermore, in total, bed days increased suggesting an increase in throughput over the period. The following data shows a similar analysis for public and private hospitals Australia-wide over a slightly different time period, since data prior to 93/94 is not available.

Table 5.7 – Public Hospitals and Bed Days by Hospital Size – Australia (93/94 to 99/00)

Average Available Beds (Hospital Size)	No. of Hospitals		Total Bed Days	
	93/94	99/00	93/94	99/00
0-49	474	512	2250882	2197822
50-199	174	154	4810622	4677741
200-399	53	52	4115792	4705252
400 +	36	25	6706420	4666999
Total	**737**	**743**	**17883716**	**16247814**

Source: AIHW, 1999-00

Table 5.8 –Public Hospital Bed Days (Rate of Change) – Australia (93/94 to 99/00)

Average Available Beds	93/94	99/00	Change	Rate of Change
0-49	2250882	2197822	-145	-0.024
50-199	4810622	4677741	-364	-0.028
200-399	4115792	4705252	1615	0.143
400 +	6706420	4666999	-5587	-0.304
Total	**17883716**	**16247814**		

Source: AIHW, 1999-00

Table 5.9 – Market share and rate of change –Public Hospital Bed Days – Australia (93/94 to 99/00)

Average Available Beds	93/94	99/00	Change	Rate of Change
0-49	0.126	0.135	0.009	0.075
50-199	0.269	0.288	0.019	0.070
200-399	0.230	0.290	0.059	0.258
400 +	0.375	0.287	-0.088	-0.234
Total	**1.000**	**1.000**		

Source: AIHW, 1999-00

For this group the number of hospitals rose over the period by 0.8 percent, with bed days falling by a total of 9 per cent (Table 5.7). This result is the opposite of that for Victorian public and private hospitals. Bed days fell by 2.6 percent for hospitals with between 0 and 199 beds and fell by 30 percent for hospitals with more than 400 beds. The medium size range with between 200 and 399 beds increased bed days by over 14 percent (Table 5.8). Despite the reduction in total bed days, all size groups with less than 400 beds experienced an increase in market share (Table 5.9). The only group with reduced market share was the largest group (23.4 percent). The number of hospitals with over 400 beds fell from 36 to 25 (31 percent) (Table 5.7). It is expected that a fall in the number of hospitals within the largest hospital group would result in a marked reduction in market share since it is the largest hospitals that provide the bulk of bed days. In other words, the actual supply of public hospital beds Australia-wide became smaller over the period, with the largest public hospitals bearing responsibility for the reduction.

The following three tables show results for Private Hospitals – Australia (91/92 – 95/96), which is an identical time period to the Victorian analysis.

Table 5.10 - Private Hospitals and Bed Days by Hospital Size – Australia (91/92 to 95/96)

Average Available Beds (Hospital Size)	No. of Hospitals		Total Bed Days	
	91/92	95/96	91/92	95/96
0-25	68	67	244900	229900
26-50	100	92	798600	747400
51-100	98	102	1534000	1721000
101-200	40	46	1353800	1864300
201+	13	16	960100	1281600
Total	**319**	**323**	**4891400**	**5844200**

Source: ABS, Private Hospitals, Australia, Cat. 4390.0

Table 5.11 –Private Hospital Bed Days (Rate of Change) – Australia (91/92 to 95/96)

Average Available Beds	91/92	95/96	Change	Rate of Change
0-25	244900	229900	-41	-0.06
26-50	798600	747400	-140	-0.06
51-100	1534000	1721000	512	0.12
101-200	1353800	1864300	1399	0.38
201 +	960100	1281600	881	0.33
Total	**4891400**	**5844200**		

Source: ABS, Private Hospitals, Australia, Cat. 4390.0

Table 5.12 - Market share and rate of change – Private Hospital Bed Days - Australia (91/92 to 95/96)

Average Available Beds	91/92	95/96	Change	Rate of Change
0-25	0.05	0.04	-0.01	-0.21
26-50	0.16	0.13	-0.04	-0.22
51-100	0.31	0.29	-0.02	-0.06
101-200	0.28	0.32	0.04	0.15
201 +	0.20	0.22	0.02	0.12
Total	**1.000**	**1.000**		

Source: ABS, Private Hospitals, Australia, Cat. 4390.0

Within this group the total number of hospitals rose by 4 or 1.25 percent (Table 5.10) and bed days rose by 19.5 percent, significantly more than either of the Victorian groups (8.5 percent for private and 10 percent for public hospitals). Bed days fell by 6.3 percent for the two combined smallest groups of between 0 and 50 beds, and rose for all larger hospital sizes (Table 5.11). Although bed days rose for the 51-100 sized hospitals, their market share fell by 6 percent (Table 5.12). The three smaller groups with 100 beds or less lost market share to the two larger groups. The larger groups gained market share with an increase in both the number of hospitals and bed days.

It is evident from this analysis that, with the exception of Public Hospitals – Australia, all groups experienced falling market share among smaller hospitals over the period. The market for public hospitals Australia-wide became smaller over the period 1993/94 to 1999/00, which is consistent with the large increase in Private Hospital usage (19.5 percent increase in bed days between 1991/92 and 1995/96) (Tables 5.10 and 5.11).

Public Hospitals in Victoria clearly experienced economies of scale over the period, with smaller hospitals losing market share due to both a reduction in the number of hospitals and a reduction in bed days. These findings are supported in the literature (Frech and Mobley, 1995 and Dranove, 1998)[27], and they are also supported by the economies of scale discussion in section 6.6 of this thesis.

These results should also be viewed in conjunction with the results of various reviews undertaken of Victorian rural hospitals. As noted in section 4.10 the Small Rural Hospitals Taskforce was established in 1993. This was followed by the Multi-Purpose Services Program Evaluation, Review of Group D and E Hospitals, Fabric Survey, and Rural Healthstreams Evaluation, among the subsequent reviews (DHS, 2002). This DHS discussion paper notes that the reviews found difficulties within the system that need to be addressed. These difficulties relate to system drivers, funding structures, access to services, priority setting, financial viability, funding

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[27] Weaver and Deolalikar (2004) find that economies of scale and scope depend on category of hospital, as well as bed number and volume of output.

cycles, compliance and reporting, and comparative performance (DHS, 2002). The effect of these issues on rural agencies could also explain the number of closures and amalgamations that were experienced by mostly rural hospitals over the period of this analysis.

'System drivers' refers to the funding system that determines the service profile. The reviews find that health and community services are not adequately provided under this system, and '…the approach…needs to be more responsive to *service need* whilst operating within a capped funding system' (DHS, 2002, p13). The various funding structures also create problems in rural areas. These problems are due to inequitable resource allocation methods, insufficiently funded programs, inadequately identified patients' impairment needs, and the fact that funding is based on average state-wide costs that are skewed toward metropolitan costs (DHS, 2002).

It is acknowledged that rural areas have a higher incidence of disease rates due to lower access to health services in Victoria. Also, in terms of priority setting, it is found that funders are not '…sufficiently aware of the services that are being 'purchased', or whether these have any bearing on service needs or service priorities' (DHS, 2002, p15). The financial viability of rural health agencies is also taken into consideration because '[a]gencies are substantially influenced by…changes to funding conditions and levels' (DHS, 2002, p15). Their ability to absorb costs, generate revenue or change services is hampered by agencies' small size. Rural areas are also sensitive to the departure of even one General Practitioner from a town.

> The dependence on external operators for the delivery of core services places agencies in a very vulnerable position, which is accentuated when funding is provided on an output basis.
> (DHS, 2002, p15).

The annual funding cycles exacerbate uncertainty in rural areas because agencies may not be aware of their annual allocation until after the financial year. The DHS recommends a switch to three year funding agreements to overcome this problem. The issue of compliance and reporting adds a further administrative burden on small agencies due to insufficient staff with adequate expertise. Comparative performance measurement is also difficult due to unreliable baseline data, and therefore '…the system has difficulty in really knowing the level of efficiency of the health and community services sector generally' (DHS, 2002, p17).

5.3 Victorian Public Hospitals – Amalgamations and Closures

The following tables list Victorian Public Hospitals for the years 1991/92 and 1995/96 by average available beds. The discussion outlines the separation of amalgamations and closures for each group size, and whether these occurred in metropolitan or regional Victoria. The hospital movements are captured by the Victorian Hospitals' Association's *Rainbow Hospital Indicators*.

Table 5.13 – 77 Public Hospitals – Victoria 91/92
Average Available Beds 0 – 49

Alexandra
Altona **(*M*)**
Apollo Bay
Bacchus Marsh **(*M*)**
Birregurra
Boort
Bright
Burwood **(*M*)**
Camperdown
Casterton
Clunes
Cobram District
Cohuna
Coleraine
Corryong
Creswick
Daylesford
Dimboola
Donald
Dunmunkle H.S.
Dunolly
Edenhope District
Eildon
Elmore
Healesville **(*M*)**
Heathcote
Heywood
Inglewood
Jeparit
Kaniva
Kerang
Kilmore
Koroit
Korumburra
Kyabram
Kyneton
Lismore District
Lorne Community
Macarthur
Maffra
Maldon
Manangatang
Mansfield
Mortlake District
Myrtleford
Nathalia
Nhill
Numurkah
Omeo
Orbost
Ouyen
Ovens District
Penshurst
Port Fairy
Portland
Ripon Peace
Rochester
Seymour
Skipton District
South Gippsland
St. Arnaud
Stawell
Tallangatta
Tatura
Tawonga District
Terang District
Timboon District
Waranga Memorial
Werribee **(*M*)**
Westernport **(*M*)**
Willaura
Winchelsea
Woorayl
Wycheproof
Yarram
Yarrawonga
Yea

M = Metropolitan area

Table 5.13 shows that in 1991/92 there were 77 public hospitals in Victoria with 0-49 average available beds. Only 6 hospitals were situated within the metropolitan area. These were Altona, Bacchus Marsh, Burwood, Healesville, Werribee and Westernport. Of these metropolitan hospitals, only Werribee was no longer operating as a separate hospital in 1995/96 (see Table 5.14) since it joined the Mercy

Public Hospitals in 1994/95 and entered the 200-399 size grouping. Healesville was renamed Yarra Ranges Health Services in 1995/96.

Of the non-metropolitan hospitals in this size range, 9 closed (Apollo Bay, Clunes, Corryong, Dunolly, Eildon, Koroit, Macarthur, Orbost and Woorayl) and 11 became amalgamated to form hospitals in the same size grouping (Table 5.14). Beechworth Hospital contains Ovens District, Gippsland Southern contains Korumburra, Rochester and Elmore combined, Corangamite contains Camperdown and Lismore, Hesse contains Winchelsea, Western Highlands contains Daylesford and Creswick, and Terang and Mortlake combined.

A number of amalgamations resulted in larger hospitals. In the 50-199 size the West Wimmera Health Service is an amalgamation of Nhill, Jeparit and Kaniva Hospitals. Dimboola amalgamated with Wimmera, and Willaura amalgamated with Ararat to form East Grampians Health Service, both within the 50-199 size. Tatura and eventually Waranga Memorial merged with Goulburn Valley and entered the 200-399 size group. Heathcote was renamed McIvor in 1994/95 and remains in the 0-49 size. One hospital (Portland) experienced an increase in average available beds and moved into the 50-199 size range. The net effect was a reduction of 16 public hospitals with between 0 and 49 average available beds over the period in Victoria. Table 5.14 shows that by 1995/96 this group size contained three new hospitals (Far East Gippsland, Otway Health and Upper Murray Health), and two that were in a larger group size in 91/92 (Benalla and Warracknabeal). Table 5.14 thus outlines the remaining 61 hospitals within this size range in 1995/96.

Table 5.14 - 61 Public Hospitals – Victoria 95/96
Average Available Beds 0 – 49

Alexandra
Altona **(*M*)**
Bacchus Marsh **(*M*)**
Beechworth Hospital, The
Benalla
Birregurra
Boort
Bright
Burwood **(*M*)**
Casterton
Cobram District
Cohuna
Coleraine
Corangamite
Donald
Dunmunkle
Edenhope District
Far East Gippsland H.S.
Gippsland Southern H.S.
Hesse R.H.S. - Winchelsea
Heywood
Inglewood
Kerang
Kilmore
Kyabram
Kyneton
Lorne Community
Maffra
Maldon
Manangatang
Mansfield
McIvor Health and C.S.
Myrtleford
Nathalia
Numurkah
Omeo
Otway Health and C.S.
Ouyen
Penshurst
Port Fairy
Ripon Peace
Rochester and Elmore D.H.S.
Seymour
Skipton District
South Gippsland
St. Arnaud
Stawell
Tallangatta
Tawonga District
Terang and Mortlake H.S.
Timboon District
Upper Murray Health
Waranga Memorial
Warracknabeal
Western Highlands
Westernport **(*M*)**
Wycheproof
Yarra Ranges H.S. **(*M*)**
Yarram
Yarrawonga
Yea

M = Metropolitan area

Table 5.15 – 25 Public Hospitals – Victoria 91/92
Average Available Beds 50 – 199

Ararat
Benalla
Colac
East Gippsland
Echuca
Fairfield **(*T*)** **(*M*)**
Gippsland Base
Hamilton Base
Maryborough
Maroondah **(*M*)**
Mordialloc **(*M*)**
Peter McCallum C.I. **(*T*)** **(*M*)**
Royal Vic. Eye and Ear **(*T*)** **(*M*)**
Sandringham **(*M*)**
St. George's **(*M*)**
Swan Hill
The Angliss **(*M*)**
Wangaratta Base
Warracknabeal
Warrnambool
West Gippsland
Williamstown **(*M*)**
Wimmera Base
Wodonga District
Wonthaggi **(*M*)**

T = Teaching Hospital *M = Metropolitan area*

Table 5.15 shows hospitals with between 50 and 199 average available beds in 1991/92. Of the 25 hospitals, 10 were located in the metropolitan area (Fairfield, Maroondah, Mordialloc, Peter McCallum Cancer Institute, Royal Victorian Eye and Ear, Sandringham, St Georges, The Angliss, Williamstown and Wonthaggi) and the remainder were located in non-metropolitan regions. Of the metropolitan hospitals, Maroondah and St Georges entered the 200-399 bed size by 1995/96. There were no amalgamations in metropolitan public hospitals of this size.

Ararat and Willaura (see Table 5.13) amalgamated to form East Grampians Health Service (Table 5.16). Benalla moved into the smaller grouping (see Table 5.14), as did Warracknabeal. East Gippsland Centre amalgamated to form Bairnsdale Regional Health Service, and Gippsland Base was the only hospital closure in this group.

Table 5.16 shows the existence of a new hospital, namely Central Wellington, and the inclusion of Portland, which was previously grouped in 0-49 average beds. This table also shows Mt. Alexander Hospital, which is the amalgamation of Castlemaine and Mt Alexander (Geriatric and Rehabilitation) hospitals. Mildura Base (Table 5.16) was previously in the 200-399 sized group, and West Wimmera Health Service was the result of the amalgamation of three hospitals previously in the 0-49 group (Nhill, Jeparit and Kaniva Hospitals).

Table 5.16 - 25 Public Hospitals – Victoria 95/96
Average Available Beds 50 – 199

Bairnsdale R.H.S.
Central Wellington
Colac
East Grampians H.S.
Echuca
Fairfield **(*T*) (*M*)**
Hamilton Base
Maryborough
Mildura Base
Mordialloc **(*M*)**
Mt. Alexander
Peter McCallum C.I. **(*T*) (*M*)**
Portland
Royal Vic. Eye and Ear **(*T*) (*M*)**
Sandringham **(*M*)**
Swan Hill
The Angliss **(*M*)**
Wangaratta Base
Warrnambool
West Gippsland
West Wimmera H.S.
Williamstown **(*M*)**
Wimmera
Wodonga District
Wonthaggi **(*M*)**

T = Teaching Hospital *M = Metropolitan area*

Table 5.17 shows hospitals with between 200 and 399 beds in 1991/92. Of the 11 hospitals listed, 6 were located in the metropolitan area and 5 in the non-metropolitan area. Non-metropolitan hospitals are Ballarat Base, Bendigo Base, Goulburn Valley Base, La Trobe Regional and Mildura Base. Of these non-metropolitan hospitals, one (Mildura Base) moved into the 50-199 size group. Of the metropolitan hospitals, Mercy Women’s amalgamated with Werribee Mercy Hospital (Table 5.13) to form Mercy Public Hospitals Inc (Table 5.18). Mornington moved into the 400+ bed size.

Table 5.17 - 11 Public Hospitals – Victoria 91/92
Average Available Beds 200 – 399

Ballarat Base
Bendigo Base
Box Hill ***(T)*** ***(M)***
Dandenong ***(T)*** ***(M)***
Goulburn Valley Base
La Trobe Regional
Mercy Women's ***(T)*** ***(M)***
Mildura Base
Mornington ***(T)*** ***(M)***
P.A.N.C.H. ***(T)*** ***(M)***
Royal Children's ***(T)*** ***(M)***

T = Teaching Hospital *M = Metropolitan area*

From Table 5.18, Maroondah and St George's were previously in the 50-199 group, and Royal Women's was in the 400+ group.

Table 5.18 - 12 Public Hospitals – Victoria 95/96
Average Available Beds 200 – 399

Ballarat Base
Bendigo H.C.
Box Hill ***(T)*** ***(M)***
Dandenong ***(T)*** ***(M)***
Goulburn Valley
La Trobe
Maroondah ***(M)***
Mercy Public Hospitals Inc ***(T)*** ***(M)***
P.A.N.C.H. ***(T)*** ***(M)***
Royal Children's ***(T)*** ***(M)***
Royal Women's ***(T)*** ***(M)***
St. George's ***(M)***

T = Teaching Hospital *M = Metropolitan area*

Table 5.19 shows hospitals with 400+ average available beds. Of the 8 hospitals, one (Geelong) is located outside the metropolitan area. MMC Clayton amalgamated with Moorabbin to form Monash Medical Centre (Table 5.20), and Royal Women's entered the 200-399 size group.

Table 5.19 - 8 Public Hospitals – Victoria 91/92
Average Available Beds 400 +

Alfred ***(T)*** ***(M)***
Austin ***(T)*** ***(M)***
Geelong ***(T)***
MMC Clayton ***(T)*** ***(M)***
Royal Melbourne ***(T)*** ***(M)***
Royal Women's ***(T)*** ***(M)***
St. Vincent's ***(T)*** ***(M)***
Western ***(T)*** ***(M)***

T = Teaching Hospital *M = Metropolitan area*

All 8 remaining hospitals in Table 5.20 are teaching hospitals.

Table 5.20 - 8 Public Hospitals – Victoria 95/96
Average Available Beds 400 +

Alfred ***(T)*** ***(M)***
Austin ***(T)*** ***(M)***
Geelong ***(T)***
Monash Medical Centre ***(T)*** ***(M)***
Mornington ***(T)*** ***(M)***
Royal Melbourne ***(T)*** ***(M)***
St. Vincent's ***(T)*** ***(M)***
Western ***(T)*** ***(M)***

T = Teaching Hospital *M = Metropolitan area*

5.4 Discussion

The results from survivor analysis clearly show a reduction in market share of Victorian public hospitals with less than 200 average available beds, whereas the market share for larger public hospitals increased over the period. This would suggest that there has been a movement away from small hospitals that are predominantly located in regional areas. Of course, these results may not be solely attributable to increased competition for casemix funding between hospitals.

The undersupply of rural doctors (see Humphreys et al., 2002 and Donato and Scotton, 1999) may also account for the fact that closures and amalgamations occurred in regional Victoria. The reduction in the number of hospitals (77 to 61) in the smallest group (0-49) supports this finding. However, the various difficulties reportedly experienced by rural agencies subsequent to the implementation of casemix funding suggest that the system does not have the '…capacity to meet the desired principles that support funding and service delivery provision' (DHS, 2002, p13). These difficulties are particularly exacerbated by an output based funding system, and also support the results obtained from survivor analysis.

Despite these observations, survivor analysis has its limitations (section 3.2), the most significant of which is that its estimates of optimality are descriptive, not normative. The healthcare sector is one industry where normative estimates are warranted because of market imperfections. The survivor technique also relies on competition to drive efficiency and, although the implementation of casemix funding mimics the competitive market to some extent, the Victorian healthcare system is not a competitive market. Limited health budgets do, however, dictate where services will be delivered, and output based funding has clearly had an impact on small hospitals located predominantly in regional Victoria.

The market for private hospitals in Victoria exhibits similar findings, with the exception of a hospital closure in the 201+ bed size. The Australia-wide results are very different in the public sector in that they show an increased market share for smaller hospitals, and a reduced market share for those with over 400 beds. Clearly the amount of closures (11) within the largest group is responsible for this anomaly. A more reflective result for economies of scale lies in the results for private hospitals

Australia-wide. Smaller hospitals in the 0-100 bed range exhibit reductions in market share, and those with over 101 beds show an increase over the period.

Chapter 6

Data Envelopment Analysis

6.1 Overview

Data Envelopment Analysis (DEA) involves the use of linear programming methods to construct a non-parametric frontier over the data so that each firm's performance can be compared to this frontier (Coelli, 1996^b). As outlined in Chapter 3 work on modern efficiency measurement began with Farrell (1957) who drew upon the work of Debreu (1951) and Koopmans (1951) to define a simple measure of firm efficiency that could account for multiple inputs under the assumption of constant returns to scale. Banker, Charnes and Cooper (1984) advanced the original work by accounting for variable returns to scale.

This application of efficiency measurement to Victorian public hospitals firstly uses Farrell's original ideas, which were input-orientated measures using two inputs and one output in an input-output ratio. With this method the technical efficiency score measures the degree of efficiency, or proximity to the efficient frontier under the assumption of constant returns to scale using the standard multi-stage DEA model. The second analysis compares technical efficiency results under the assumption of constant returns, with results under the assumption of variable returns to scale (Banker, Charnes and Cooper, 1984). Technical efficiency is defined by Coelli (1996^b) as the ability of a firm to obtain maximal output from a given set of inputs. It can also be defined as minimising inputs to produce a given level of output.

Since data have been gathered for five hospital groups (according to size) over four years, each hospital's technical efficiency scores within each group in a given year can be compared to its own scores in other years, as well as to other hospitals' scores. The first analysis also bundles total hospitals for each year, so that each hospital may be compared with all other Victorian hospitals. Since there are closures and amalgamations occurring over the period, the total sample becomes smaller over time.

Hospital size is determined by the number of separations per annum, with total output measured using weighted inlier-equivalent separations (WIES) and total inpatients treated. Inputs include non-medical staff (nursing, admin/clerical, medical support and hotel and allied) and average available acute beds. The data for this analysis has been gathered from the Victorian Hospital Comparative Data set (Victorian Hospitals' Association, 92/93-95/96).

6.2 Analysis Assuming Constant Returns to Scale

The first DEA utilised in this study uses Farrell's (1957) original ideas. These were input-orientated measures using two inputs and one output in an input-output ratio. Therefore, we take inputs x_1 and x_2, which are used to produce output y under the assumption of constant returns to scale. Since data are segregated into hospital groups according to their size (ie number of separations per annum), variable returns are not assumed within this model. The results are shown in graphical form in Appendix 1 at the end of this thesis.

Under the assumption of constant returns to scale, all inefficiencies are of a technical nature. Technically efficient firms always lie on the frontier and, indeed, form the efficient frontier. The following diagram is similar to the one shown in Chapter 3, and depicts the basic model.

Figure 6.1 – Piecewise Linear Convex Isoquant

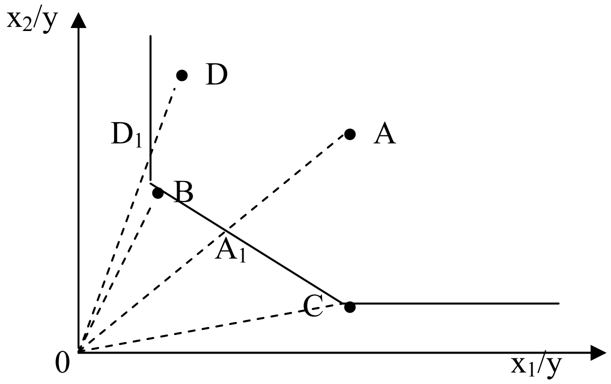

Figure 6.1 shows a constant returns to scale DEA model showing technical efficiencies. Since the model is input-orientated and we are attempting to minimise inputs, all firms lie either on or to the right of the technically efficient frontier. The

degree of technical efficiency is measured by a ray from the origin to a firm (eg, firm A). Where this ray passes through the frontier is the optimum input/output combination (A_1). The distance A_1A represents the amount by which inputs should be reduced without incurring a reduction in output. Hence, the technical efficiency score is obtained by the ratio $0A_1/0A$.

Points B and C lie on the frontier. This would make their technical efficiency score equal to 1 since there is no input reduction necessary. Firm D will lie on the frontier at point D_1, however, this is not an optimal point since the frontier at this point is parallel to the axis. At point D_1 there exists input slack equal to the distance BD_1. The input slacks obtained for this first analysis can be found in Appendix 2 (raw results)[28]. Thus, it is clear that technically efficient firms determine the shape of the frontier and set the benchmark for all firms.

Fig. 6.1 illustrates the DEA frontier corresponding to equation 6.1 below.

$$\begin{aligned} &\min_{\theta\lambda} \theta, \\ \text{st} \quad &-y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0, \\ &\lambda \geq 0, \end{aligned} \qquad (6.1)$$

where θ is a scalar and λ is a N x 1 vector of constants. The value of θ obtained will be the efficiency score obtained for the i-th hospital. It will satisfy $\theta \leq 1$, where a value of 1 indicates a hospital which is technically efficient and which lies on the frontier. The λ's represent peer weights where input slack exists (eg., point D_1 in Fig. 6.1) and where, even though there is no input slack (eg., point A_1), the technically efficient point occurs between two input combinations that determine the frontier (eg., points B and C).

DEA is useful in its application to hospitals because it helps to identify best practice in the use of resources. It should be noted, however, that efficiency is only one element of a hospital's objectives. The provision and quality of medical care are clearly the main objectives of public hospitals, and no attempt is made in this study to compare hospitals for quality outcomes.

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[28] Appendix 2 contains raw results that are produced on in excess of 1,000 pages, making them too bulky for attachment. The author is able to provide a copy of Appendix 2 upon request.

6.3 Data

Data for this study has been drawn from the Victorian Hospital Comparative Data set for each of four years (Victorian Hospitals' Association, 1992/93-1995/96). In particular, this DEA model requires one output and two inputs for each firm. Although the data set contains a multitude of possible input/output combinations, it was decided to use the number of equivalent full-time non-medical staff (ie, nursing, administrative and clerical, medical support, and hotel and allied) (input x_1) and the number of average available acute beds (input x_2).

Following scrutiny of the data, it was decided to use two different outputs for comparative purposes. The first is weighted inlier equivalent separations (WIES) (output YA). The second part of this analysis uses the same inputs with total inpatients treated (output YB). In this way it also becomes clear how the DRG weights in the WIES figures affect each hospital's technical efficiency score.

There are some data inconsistencies that are acknowledged. The output YB initially used is inpatients treated, however this is substituted for acute separations for the final two years of the study due to a change in data assembly. This inconsistency is applied to all hospitals; therefore although comparisons are less than completely reliable from year to year, cross-sectional comparisons are not affected. Also, continuity of hospital numbering requires that any new hospitals established over the period that were not the result of amalgamation, be ignored. Where an amalgamation occurs, the combined hospitals' data are entered as data of the larger pre-existing hospital.

6.4 CRS Results

Appendix 3 shows the technical efficiency scores obtained, and Table 6.1, which follows, is a proportional summary of technical efficiency scores obtained from this DEA model. The most technically efficient hospitals in each year have a score equal to 1, with the least efficient hospitals scoring <0.5. The results show some very interesting patterns. Firstly, scores for Group 'A' Teaching Hospitals show an increase in the percentage of hospitals lying on the frontier toward the end of the time period, in particular for output YA (WIES). This group has no hospitals performing in the <0.5 range, with the exception of the final year for output YB (inpatients treated/acute separations) when over 6 per cent of hospitals operate within this range. The bulk of hospitals' results are in the mid range, with their percentage falling over the period for both outputs.

Table 6.1 - Percentage of Hospitals by Group within Technical Efficiency Score Ranges, 1992/93 – 1995/96 for WIES[29] (YA) and Inpatients Treated[30] (YB) for Constant Returns to Scale

Hospital Group	Out-put	92/93			93/94			94/95			95/96		
		<0.5	0.5<1	= 1	<0.5	0.5<1	= 1	<0.5	0.5<1	= 1	<0.5	0.5<1	= 1
Group 'A' Teaching Hospitals	YA	0	93.75	6.25	0	87.5	12.5	0	87.5	12.5	0	81.25	18.75
	YB	0	93.75	6.25	0	87.5	12.5	0	87.5	12.5	6.25	81.25	12.5
Group 'B' Large Regional Base and Suburban	YA	9.1	77.27	13.64	0	85.7	14.3	0	95.2	4.8	4.8	81	14.3
	YB	4.5	82	13.64	0	85.7	14.3	4.7	81	14.3	14.3	76.2	9.5
Group 'C' Regional General Hospitals	YA	83.3	12.5	4.2	21.7	69.5	8.8	26	69.5	4.5	21.7	73.8	4.5
	YB	79	16.8	4.2	70	25.5	4.5	87	8.5	4.5	95.6	0	4.4
Group 'D' Area Hospitals	YA	86.4	9.1	4.5	13.5	82	4.5	15	75	10	35	60	5
	YB	36.4	50	13.6	32	59	9	50	40	10	45	45	10
Group 'E' Local Hospitals	YA	90.6	6.3	3.1	42	54.8	3.2	50	45.5	4.5	28.5	62	9.5
	YB	46.9	50	3.1	55	42	3	63.5	32	4.5	52.5	38	9.5
All Hospitals	YA	94.8	4.3	0.9	40.7	56.6	2.7	41	57	2	40.6	58.4	1
	YB	75.8	23.3	0.9	66.4	32.7	0.9	74.5	24.5	1	96	3	1

The results for Group 'B' (Large Regional Base and Suburban Hospitals) show a similar increase in technical efficiency over the period. There was one closure in this group; a hospital situated in regional Victoria. Although this closure occurred at the end of 93/94, the hospital does not appear to have been performing poorly prior to closure. Clearly, the bulk of hospitals within this group performed in the mid range over the period with little fluctuation over time.

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[29] WIES = Weighted inlier equivalent separations

[30] YB is inpatients treated for the first two years and acute separations for the final two years.

Group ‘C’ (Regional General Hospitals) contains hospitals which have between 1000 and 4000 separations per annum. This set of results shows the bulk of hospitals occurring in the <0.5 range at the beginning of the period. In the final year this figure falls considerably for output YA (21.7%) and rises for output YB (95.6%). The percentage of hospitals lying on the frontier is fairly stable throughout the period with most of the redistribution occurring between the two lower ranges.

Group ‘D’ (Area Hospitals) contains hospitals with between 500 and 1000 separations per annum. Efficiency scores for output YA improve over the period with a reduction of hospitals in the lowest range and an increase in the mid range. Results for output YB show a slight increase in the proportion of hospitals in this range. There were two hospital closures in this group, both at the end of 93/94.

The group with the smallest hospitals is Group ‘E’ (Local Hospitals) with less than 500 separations per annum. This group exhibited the bulk of closures (6) and amalgamations (9). All hospitals in group ‘E’ are located in regional Victoria. In regard to output YA, it is clear that the bulk of hospitals occur in the smallest range at the beginning of the period, with the bulk (62%) of hospitals in 1995/96 being in the mid range. There is an improvement in the proportion of hospitals lying on the frontier for both outputs. This figure rises from 3.1 per cent to 9.5 per cent over the period.

The results show that teaching hospitals were more closely aligned with each other at the beginning of the period than were any of the other groups. With an increase in efficiency came a slightly wider distribution of hospitals within this group. Of interest when viewing the five hospital groups separately is that, of the hospitals that performed on the technically efficient frontier at any point in the period, none was required to either amalgamate or close.

The results for All Hospitals show a slight increase in the proportion of hospitals that lie on the frontier and (for YA) a redistribution from the lowest range of efficiency to the mid range, which represents an improvement. Output YB shows a deterioration since the number of inpatients treated (or acute separations) does not take into account case complexity and, therefore, is not an accurate measure for comparison across hospital sizes. All hospitals that eventually closed performed poorly relative to the others just prior to closure, as did most of the hospitals that eventually amalgamated. A large proportion of the hospitals that resulted from amalgamation experienced an improvement in their technical efficiency scores for WIES, but not necessarily for inpatients treated/acute separations.

Appendix 1 contains graphs of the DEA results in 1992/93 and 1995/96 for each separate group and each input/output combination, as well as for all hospitals. The graphs illustrate that the majority of hospitals improve their technical efficiency over the period. This is evident in both the overall movement of hospitals in a south-westerly direction as well as the re-positioning of the efficient frontier.

The frontiers for Group ‘A’ and Group ‘B’ hospitals have clearly shifted down and to the left over the period for both outputs. The frontier for Group ‘C’ hospitals has also improved slightly with the hospitals that were operating at a greater distance from the frontier in 92/93 improving their position. Group ‘D’ hospitals experienced an improvement for output YB in both positioning of the frontier and efficiency improvement among the poorer performers. Their performance in terms of output YA appears to have deteriorated over the period. Group ‘E’, with the exception of hospital 10, also experienced an improvement for output YB and deterioration in the ratio of inputs to YA. The graphs for all hospitals tell a similar story for both outputs, with the exception of hospital 30, which shows a distinct reduction in efficiency over the period.

The results suggest that some improvement has occurred in hospitals’ technical efficiency over time. Since the study covers the time period 92/93 to 95/96, and since casemix funding was implemented on 1 July, 1993, it can be inferred that casemix funding had some impact on these results. The fact that Group ‘E’ hospitals experienced poor efficiency scores when compared with all other hospitals, suggests that these hospitals found it difficult to compete under the new output based funding regime. The evidence of amalgamations within this group also suggests that these small, regional hospitals attempted to remain competitive by increasing their size in order to secure funding (see section 5.3).

6.5 Variable Returns to Scale

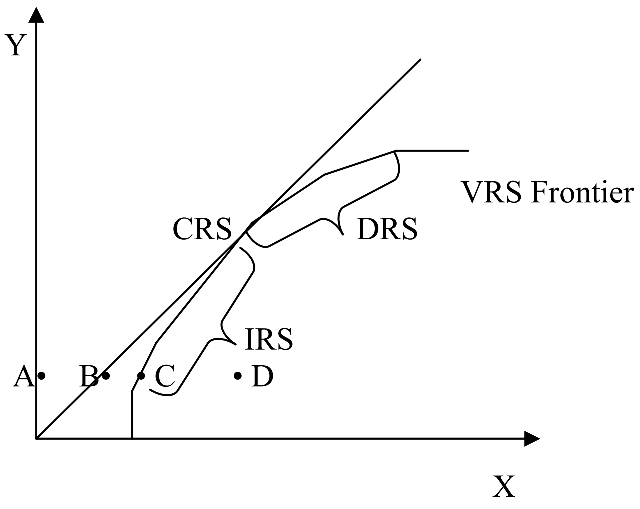
The major assumption of Farrell's (1957) model is that of constant returns to scale. This may be oversimplifying the analysis since it suggests that all hospitals in the study operate at optimal scale, namely at the minimum of long-run average costs. It is conceivable that this is not the case, in fact, due to the many financial constraints that hospitals face. In particular, the adoption of new technology in the longer term results in increasing costs for hospitals, as opposed to cost savings in other industries (Rice, 1998).

This section utilises the Banker, Charnes and Cooper (1984) DEA model which extends Farrell's (1957) work, and which accounts for variable returns to scale situations. This model removes the scale efficiency effects, leaving measures of technical efficiency. (See Appendix 4 for technical efficiency scores, and Appendix 5.1 and 5.2 for raw results, and 5.3 for graphs).

The Banker, Charnes and Cooper (1984) model contains both VRS and CRS DEA results generated from the same data in order that comparison between the two can be made. Where there is a difference between the two technical efficiency scores, this indicates the existence and degree of scale inefficiency (Coelli, 1996[b]). This model uses one input and one output, namely EFT non-medical staff and WIES respectively. The shape of the frontier is a convex hull which envelopes the data points more tightly than the CRS conical hull (Coelli, 1996[b]). Since this is the case, technical efficiency scores will be greater than or equal to those obtained using the CRS model.

Whereas in the model used earlier in this chapter efficiency was measured by a ray from the origin, this model measures efficiency horizontally. This shows by how much the use of the input should be reduced to produce the same level of output. Figure 6.2 illustrates the model and shows how efficiency is obtained.

Figure 6.2 – Scale Efficiencies



In Figure 6.2 the distance DC shows technical inefficiency of point D under the assumption of VRS, whilst under CRS the technical inefficiency is the larger distance DB. This can be expressed as follows:

$$TE_{CRS} = AB/AD$$

$$TE_{VRS} = AC/AD$$

$$SE = AB/AC$$

$$TE_{CRS} = TE_{VRS} \times SE$$

$$AB/AD = (AC/AD) \times (AB/AC)$$

Therefore, scale efficiency multiplied by technical efficiency under the assumption of variable returns to scale is equal to technical efficiency under the assumption of constant returns to scale.

6.6 VRS Results

The results for CRS, VRS and scale obtained using the Banker, Charnes and Cooper (1984) model are summarised in Table 6.2. Between 1992/93 and 1995/96 there is a reduction in the proportion of hospitals in the least efficient range (<0.5) for CRS and VRS assumptions, and scale. A reduction in the figure for scale in this range suggests an improvement in scale economies since hospitals in this group either increased output or reduced input (see Figure 6.2 for clarification). There also appears to have been a redistribution of hospitals from the least efficient range to the mid range in Table 6.2, with the proportion of hospitals lying on the VRS frontier increasing. The VRS frontier has, therefore, shifted up over the period, leaving those hospitals that did not improve their relative position (eg. hospital 85 in Appendix 5.3 graphs) operating at a greater distance from both frontiers. It is also clear from Appendix 5 that hospital 62's position has deteriorated, with a proportionally larger increase in input than output.

Table 6.2 - Percentage of All Hospitals within Technical Efficiency Score Ranges for 1992/93 and 1995/96 for CRS, VRS and Scale[31]

Technical Efficiency	**92/93**			**95/96**		
	<0.5	**0.5<1**	**= 1**	**<0.5**	**0.5<1**	**= 1**
CRS	95	4.1	0.9	85	14	1
VRS	70	27	3	59	35	6
Scale	22	76	2	5	94	1

The results (graphs) obtained using the Banker, Charnes and Cooper (1984) model show that between 1992/93 and 1995/96 hospitals 2, 6, 109 and 66 improved their relative positions. With the exception of hospital 6, these hospitals form the north-western frontier. The VRS frontier has shifted up over the period, leaving those hospitals that did not improve their relative position over the period (eg. 85) operating at a greater distance from both frontiers. It is clear that hospital 62's position has deteriorated, with a larger proportional increase in input relative to output.

This model also gives results for increasing and decreasing returns to scale. Hospitals producing output at less than the CRS level of output exhibit increasing returns to scale (IRS), and hospitals producing above the CRS level of output exhibit decreasing returns to scale (DRS). The results show that over time the IRS section of the VRS frontier becomes smaller. This is due to the following. Firstly, the hospital operating at CRS in 1992/93 (hospital 119) used 49 inputs to produce 3224 outputs

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[31] Scale represents the distance AB/AC from Fig. 6.2 above.

(1.5 percent of the output figure). In 1995/96 hospital 15 was operating on the CRS frontier and used 30 inputs to produce 1565 outputs (1.92 percent of the output figure). There were 72 hospitals operating on the IRS section of the frontier in 1992/93, compared with 52 hospitals in 1995/96. These results are consistent with the amalgamation behaviour outlined in Chapter 5 and Section 6.3 above.

Comparing these technical efficiency scores to those obtained using Farrell's (1957) model, the results show the same hospitals operating on the CRS frontier. In 1992/93 (Appendix 3.6) hospital 119 has a score equal to 1.000 for output YA (WIES). In 1995/96 (Appendix 3.6) there are two hospitals in this position (15 and 84). Using the Banker, Charnes and Cooper (1984) model, hospital 84 is 44.8 percent efficient (CRS) and 74.4 percent efficient (VRS) in 1995/96. Bearing in mind that the Farrell (1957) model analysis earlier in this chapter includes an additional input (average available beds), it is apparent that the absence of beds in the analysis reduces the efficiency score for hospital 84[32], although average available beds are not the sole determinant of efficiency.

Not surprisingly, all Group 'A' teaching hospitals and Group 'B' large regional hospitals appear on or near the DRS portion of the frontier. That is, an increase of the input would result in a less than proportional increase in output. In 1995/96 hospital 15 (C5) is the only hospital operating at the minimum point of its long-run average cost curve. This is consistent with the Farrell (1957) model results and shows that the two models support the finding that hospital 15 operated at the optimal input/output combination in 1995/96 under the assumptions of both CRS and VRS.

6.7 Discussion

This chapter has illustrated the use of linear programming methods to construct non-parametric frontiers over Victorian hospital data. Both methods used have generated technical efficiency scores for the data, allowing us to compare hospitals' performance over time. It is interesting to note that there was only one hospital (15) that performed consistently on the efficient frontier using these methods. This was a

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[32] The Banker, Charnes and Cooper (1984) model analysis uses only non-medical staff as the input.

medium sized hospital located in the metropolitan area. Of note is the result that hospitals that either closed or amalgamated did not register an efficiency score equal to 1 for the entire period. Although one or two may have been operating at above 70 per cent efficiency, on the whole closures were poor performers relative to their peers.

The CRS graphs for the first and final years of observation (Appendix 1) illustrate the input/output ratios between the two periods. These graphs suggest that the pressure of budget cuts and competition for casemix funding had only a slight impact on individual public hospital efficiency. A movement in the frontier over time suggests that there was room for improvement even among hospitals that were technically efficient at the beginning of the period. Hospitals operating at a greater distance from the frontier, that later moved in a south-westerly direction, appear to show some improvement in efficiency.

The literature contains considerable debate[33] over whether or not hospital efficiency should be measured using frontier estimation techniques; there is also division within frontier approaches. Proponents of SFE note that DEA does not *estimate* the frontier, rather the frontier is *derived*. This leaves DEA results sensitive to the sample, such that the technical efficiency scores cannot determine if hospitals on the frontier are also inefficient (Craycraft, 1999). SFE, however, is a parametric approach that is based on 'statistical assumptions that allow the frontier to be estimated from the data' (Craycraft, 1999, p 23). Kooreman (1994^b) suggests that the two techniques (DEA and SFE) address different questions and serve different purposes.

> At the present, state of the art of the two approaches should primarily be viewed as complements rather than substitutes. Further research, preferably based on panel data, should try to combine the strengths of both.
> (Kooreman, 1994^b, p 345)

In an effort to bring together the strengths of both techniques, therefore, our analysis continues in the following chapter with an application of SFE to Victorian hospital data over the same period.

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[33] The debate is outlined here in Chapter 2 and was originally published in the Journal of Health Economics, 1994, Vol 13, Issue 3.

Chapter 7

Stochastic Frontier Estimation

7.1 Overview

The stochastic frontier production function was independently proposed by Aigner, Lovell and Schmidt (1977), and Meeusen and van den Broeck (1977). This new approach to estimating production functions involves the 'specification of the error term as being made up of two components, one normal and the other from a one-sided distribution' (Aigner et al., 1977, 21). Thus, the stochastic frontier model has the advantage over DEA in that it is now able to decompose the two sources of error into random noise and inefficiency (Dor, 1994). In its original form the model was specified for cross-sectional data, as outlined below in equation (7.1), although the entire error term ($v_i - u_i$) could not be decomposed.

$$Y_i = x_i\beta + \varepsilon_i \tag{7.1}$$

Where Y_i is the production (or the logarithm of the production) of the i-th firm;

x_i is a k x 1 vector of (transformations of the) input quantities of the i-th firm;

β is a vector of unknown parameters;

$\varepsilon_i = v_i - u_i$

v_i is a two-sided error term representing statistical noise which is assumed to be independently and identically distributed as $N(0,\sigma_v^2)$ and independent of u_i, where,

u_i is the one-sided error term representing technical inefficiency and satisfies: $u_i \geq 0$

Aigner et al. (1977) acknowledge that there is economic logic in stating that the production process is subject '…to two economically distinguishable random disturbances, with different characteristics' (Aigner et al., 1977, 24). They go on to state that since each firm's output must lie either on or below its frontier, any deviation from the frontier must be due to either factors under the firm's control (technical and economic inefficiency) or, what the authors term, bad luck, climate and machine performance.

In Jondrow et al., (1982) the authors refine the stochastic production function[34] by considering the expected value of u, conditional on (v – u) and decomposing the error term into random noise and technical inefficiency. This advance allows the *estimation* of technical inefficiency u_i for each observation.

> …this was Farrell's (1957) original motivation for introducing production frontiers, and the ability to compare levels of efficiency across observations remains the most compelling reason for estimating frontiers.
> (Jondrow, et al., 1982, p 234)

In Schmidt and Sickles (1984), the authors outline their application of the stochastic frontier production function using panel data for U.S. domestic airlines to identify firm-specific productive efficiency. The paper recognises that the use of cross-sectional data results in the SFE having three major deficiencies. The first of these is that technical inefficiency (u_i) for a firm cannot be estimated *consistently*. Despite the fact that the whole error term (v – u) can be estimated consistently, it contains statistical noise as well as inefficiency. Simply increasing the sample size does not eliminate variance of the distribution of technical inefficiency. According to Schmidt and Sickles (1984) this problem is overcome with the use of panel data since increasing the observations on each firm ($T \rightarrow \infty$) results in better information being obtained than by adding more firms.

The second problem identified relates to assumptions about the distribution of technical inefficiency. Technical inefficiency is assumed to be distributed half-normally, and statistical noise is assumed to have a normal distribution. Schmidt and Sickles (1984) point out that these assumptions may not reflect the results obtained. In particular they note that evidence of technical inefficiency is skewness of the production function error, however it is not necessarily the case that skewness should be regarded as evidence of inefficiency. By using a panel, there is no need to make strong distributional assumptions. This is because inefficiency can be found in constancy over time as well as in skewness.

Finally, Schmidt and Sickles (1984) find that cross-sectional models require that inefficiency is independent of the regressors. However, as they note, if a firm knows

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[34] Prior to Jondrow et al., (1982) only the composed error term, ε_i, was estimated for each observation.

its level of technical inefficiency, then they would change their input choices. The use of a panel eliminates the need to make such an assumption, since estimates of the parameters and of the firms' inefficiency levels can still be obtained.

Battese and Coelli (1995) define a stochastic frontier production function using panel data to estimate technical inefficiency effects. The authors note that previous papers involve a two-stage approach to this estimation. The first stage involves estimating the stochastic frontier production function and predicting the technical inefficiency effects under the assumption that these inefficiency effects are identically distributed. In the second stage the *predicted* technical inefficiency effects are regressed. This contradicts the assumption of identical distribution made in the first stage. In their article the authors propose a one-stage model which allows for the estimation of both technical change in the stochastic frontier and time-varying technical inefficiencies. This is the model applied in this section for estimation of a production function using Victorian Comparative Data for the years 1992/93 to 1995/96.

7.2 Model for Panel Data

The use of panel data involves observing data on hospitals (cross-sectional) over time (time-series). The one stage stochastic frontier production function proposed by Battese and Coelli (1995) takes the general form:

$$Y_{it} = \exp(x_{it}\beta + V_{it} - U_{it}) \qquad (7.2)$$

Where Y_{it} = production at the t-th observation (t = 1,2,….T) for the i-th firm (i = 1,2,….N).

WIES have been chosen as the dependent variable since these are separations weighted by DRG.

x_{it} = a (1 x k) vector of values of known functions of inputs of production for the i-th firm at the t-th observation.

These independent variables (regressor variables) are average available beds, nursing staff, administration/clerical staff, medical support staff, hotel and allied staff and year of observation.

β = a (k x 1) vector of unknown parameters to be estimated.

V_{it} = assumed to be iid $N(0, \sigma_v^2)$ random errors, independently distributed of the U_{it}s.

U_{it} = non-negative random variables associated with technical inefficiency of production, which are assumed to be independently distributed, such that U_{it} is obtained by truncation (at zero) of the normal distribution with mean, $z_{it}\delta$ and variance σ^2 (Coelli, 1996[a]).

The inputs chosen for the stochastic frontier model all had available data for at least one year of observation, which is a requirement of the model. Staff numbers were chosen because they are a significant factor in a hospital's production. Labour is also an area where we would expect some variation between hospitals depending on hospital size and location. We would expect increased use of labour to have a positive effect on output due to the assumption of monotinicity in the properties of production functions (Chambers, 1997, p 9).

Average available beds were chosen since bed availability would be expected to vary among hospitals and be positively correlated with output. We would expect that hospitals with larger bed numbers are able to support more weighted inlier equivalent separations (Chambers, 1997). There is doubt in the literature as to the appropriateness of using available beds as a measure of hospital size. Butler (1995) states that this is an imperfect measure of the scale of a hospital's operations because beds are not all interchangeable. Butler cites Berki (1972) in pointing out that intensive care beds, paediatric beds and obstetric beds are not substitutable for medical or surgical beds. For the purpose of this study, however, WIES are a function of available beds, although it is possible for beds to be underutilised at any point in time.

The technical inefficiency effect, U_{it} from model (7.2) is specified as:

$$U_{it} = z_{it}\delta + W_{it} \tag{7.3}$$

Where z_{it} is a (1 x m) vector of explanatory variables associated with technical inefficiency of production of firms over time.

δ is an (m x 1) vector of unknown coefficients.

W_{it} is the random variable defined by the truncation of the normal distribution with zero mean and variance, σ^2, such that the point of truncation is $-z_{it}\delta$, i.e., $W_{it} \geq -z_{it}\delta$.

The explanatory variables in the inefficiency model are three dummy variables, which have been used so that some explanation can be given for inefficiency. The first of these has hospitals grouped into Metropolitan with a value of 1 and Non-metropolitan with a value of 0. This explanatory variable will show whether or not geographical location has any effect on inefficiency, given the different level of concentration in each location. Vogel and Miller (1995), a study of market concentration among hospitals, show that highly concentrated markets (monopolies) result in lower costs.

Vogel and Miller (1995) examine the variations in rural hospital costs using U.S. data, and find that hospitals located in highly concentrated rural communities have lower costs per day than other non-metropolitan hospitals. They also find that metropolitan hospitals follow a similar trend in that increased competition in this market leads to increased costs. Specifically, metropolitan hospitals exhibit cost-increasing competition due to what they term a ‘technological arms race’ (Vogel and Miller, 1995, p 81). This form of competition based on acquisition of the latest technology is not evident in highly concentrated rural communities. The authors also find, however, that in other non-metropolitan hospital markets (with > 1 hospital) increased competition brings about lower costs, which is consistent with economic theory.

The second dummy variable groups hospitals into Teaching with a value of 1 and Non-teaching with a value of 0. Some metropolitan hospitals in this study are non-teaching, and one non-metropolitan hospital is a teaching hospital. This variable should also give an indication as to whether or not teaching responsibilities have an impact on inefficiency. The increased burden on teaching hospitals may have an impact on efficiency since it would involve increased costs of teaching and research not associated with non-teaching hospitals (Duckett, 1999). However, there is evidence to suggest that, once adjustment is made for casemix, the existence of university funds (for staff salaries etc.) and the utilisation of lower paid students, the impact of teaching is not as significant as previously thought (Butler, 1995, p 247).

The final dummy variable is the year of observation. This will show how inefficiency has changed over time. As discussed earlier, the objective of casemix funding is for hospitals to improve efficiency over time in order to secure increased funding. In this study, year of observation appears in both models (7.2) and (7.3). In the stochastic frontier model (7.2), the year variable accounts for Hicksian neutral technological change, and in the inefficiency model (7.3), the year of observation shows that the inefficiency effects may change linearly over time.

Within the inefficiency model we would expect larger metropolitan hospitals to be less inefficient than their regional counterparts, representing economies of scale in production. Since most teaching hospitals are located in the metropolitan area, we would expect that these are also less inefficient than non-teaching hospitals. Over time we would expect inefficiency to decline since casemix funding imposes pressure on hospitals to reduce input costs.

7.3 Results[35]

The results for the one stage model comprising both stochastic frontier production function and technical efficiency effects using the above variables are set out in Tables 7.1, 7.2 and 7.3. All variables in Table 7.1 have been logged so that coefficients may be read as elasticities.

Table 7.1: Stochastic Frontier Results

Explanatory Variables	Coefficient	Standard Error	t-ratio
Constant	4.2005	(0.138)	30.320
*l*n Average Available beds	0.797	(0.061)	12.905
*l*n Nursing Staff	0.178	(0.077)	2.301
*l*n Admin/Clerical Staff	0.271	(0.049)	5.527
*l*n Medical Support Staff	-0.005	(0.029)	-0.176
*l*n Hotel and Allied Staff	-0.196	(0.066)	-2.937
Year	-0.030	(0.017)	-1.707

Table 7.2: Inefficiency Model Results

Explanatory Variables	Coefficient	Standard Error	t-ratio
Constant	-0.357	(0.164)	-2.174
Metropolitan location	-3.275	(0.330)	-9.922
Teaching	-1.391	(0.239)	-5.815
Year	0.008	(0.058)	0.149

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[35] For full raw results, refer to Appendix 6 attached.

Table 7.3: Statistical Summary

Statistic	Coefficient	Standard Error	t-ratio
Log Likelihood Function	-108.45		
σ^2	0.412	(0.041)	9.984
est γ	0.9018	(0.0209)	43.025
L-R Test of one-sided error	114.69		

The signs from the results are mostly as expected. In the stochastic frontier model positive signs for average available beds, nursing staff and admin/clerical staff suggest that a one unit increase in each of these variables results in an increase in the WIES figure. The sign for medical support staff is small and negative; indicating negative marginal product, but the t-ratio is less than 2. The sign for hotel and allied staff is also negative and shows that a one unit increase in this input results in a 0.19% decrease in WIES. Although this is not a large percentage change, it suggests that this input also has negative marginal product, which is a counterintuitive result. The first three inputs, and hotel and allied staff, are statistically significant with t-ratios exceeding 2.

The majority of signs in the inefficiency model are as expected. The result for metropolitan/non-metropolitan hospitals suggests that if a hospital is located in the metropolitan area, it reduces the inefficiency effect by over 3 per cent. Teaching hospitals also have a negative relationship and therefore teaching hospitals also reduce the inefficiency effect compared to non-teaching hospitals. This is consistent with Butler's (1995) findings. The fact that most teaching hospitals are located in the metropolitan area may explain this result. Over time it is not evident whether the inefficiency effect changes linearly since the result is not statistically significant.

The null hypothesis that the inefficiency parameters equal 0 ($\delta_1 = \delta_2 = \delta_3 = 0$) is rejected at the $\chi^2_{0.95,\,3}$ value[36]. In Table 7.3 the estimate for the variance parameter (gamma) is close to 1; therefore, taken together, the inefficiency effects are likely to be highly significant in the analysis of weighted inlier equivalent separations.

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[36] H_o: $\delta_1 = \delta_2 = \delta_3 = 0$ has a Log (Likelihood) = -131.073
Therefore: $\lambda = -2\{-131.073 - [-108.45]\} = 45.22$
Where $\chi^2_{0.95,\,3} = 7.81$, $45.22 > 7.81$, therefore reject H_o.

The δ parameter in equation (7.3) is a time-invariant parameter. In order to test this assumption, an OLS model was estimated in three different specifications; one, allowing δ to differ across four years for both variables, and for the two remaining specifications, allowing δ to differ across four years for one and then the other variable. The time variation in the parameter was tested by comparing the first specification with each of the two restricted specifications. The F-test statistic fails to reject H_o that the coefficients do not change over time. Thus, the null hypothesis is accepted that the δs do not change significantly over the four years.

Table 7.4 sets out a summary of the technical efficiency estimates for the hospitals in this study.

Table 7.4: Summary of Technical Efficiency Estimates by Year of Observation (Number and %)

Year		< 0.5	0.5	0.6	0.7	0.8	0.9	1	Total Hospitals
1	No.	5	9	11	26	31	34	0	116
	%	4.3	7.8	9.5	22.4	26.7	29.3		
2	No.	18	4	13	22	32	23	0	112
	%	16	3.6	11.6	19.6	28.6	20.5		
3	No.	10	8	6	26	22	30	0	102
	%	9.8	7.8	5.9	25.5	21.6	29.4		
4	No.	8	7	7	24	27	28	0	101
	%	7.9	6.9	6.9	23.8	26.7	27.7		

Note: Using a Chi-squared test, the null hypothesis was not rejected, indicating that there has not been any significant change in proportions over time.
$X^2 = 17.382 < X^2_{0.95,\,15} = 24.996$

In Table 7.4 technical efficiency is a measure between 0 and 1 with 1 being technically efficient and 0 being completely inefficient. It is clear that no hospital lies on the efficiency frontier (= 1), unlike the case for the DEA model where the frontier is derived from the data. Overall, the number of hospitals in the study fell from 116 to 101. This was due to hospital closures and amalgamations. Over the four year period, the number of hospitals that are 90 per cent efficient fell from 34 to 28. Similarly, the number of hospitals operating within the 80 per cent efficiency group fell from 31 to 27. These numbers as a percentage of the total do not change to any extent for both of these groups. Table 7.5 below shows hospitals' technical efficiency score groups prior to closure or amalgamation.

Table 7.5: Efficiency Score Results of Hospitals Prior to Closure or Amalgamation

Hospital*	Year 1	Year 2	Year 3
31 *R*#	<0.5		0.7
34 *R*	0.5		
54 *R*	<0.5		
103 *M*	0.9		
4 *R*	0.8	0.6	
19 *R*	0.6	0.5	
24 *R*	0.7	0.6	
25 *R*	0.8	0.6	
37 *R*	0.8	0.8	
44 *R*	0.5	<0.5	
47 *R*	0.8	<0.5	
52 *R*	0.7	<0.5	
66 *R*	0.6	<0.5	
72 *R*	0.7	0.8	
107 *R*	0.9	<0.5	
28 *R*	0.9	<0.5	<0.5

** None of the above hospitals (except 31) was operating in Year 4.*
#Hospital 31 did not close, but data was not available for Year 2. It is included here so that total hospital numbers correspond with Table 7.4.
R = Regional Hospital M = Metropolitan Hospital

With the exception of hospitals 37, 72 and 103, all hospitals that closed or amalgamated experienced declining efficiency just prior to ceasing operations. It is possible that either the threat of reduced funding, or the fact of it, has been the cause of these closures. Of the results shown in Table 7.5, none of the hospitals noted were teaching hospitals, and only one was located in the metropolitan area.

From Table 7.4 it is clear that the number of hospitals operating at <0.5 efficiency rose initially and then fell at the end of the period. The same can be said for those operating at 0.6 efficiency. The hospital numbers operating within 0.5 and 0.7 efficiency remained fairly stable over the period. These results also suggest that even the most efficient hospitals could reduce inputs by approximately 10 per cent and still maintain current output levels.

7.4 Discussion

The SFE results suggest that casemix funding does not appear to have had an effect on hospital efficiency over the four year period. It does appear, however, that casemix funding has had an effect on hospital closures in the Victorian public hospital sector, especially in regional areas. According to the results, efficiency gains were only made in metropolitan teaching hospitals. The stochastic model shows a positive relationship between the first three inputs (average available beds, nursing staff and admin/clerical staff) and output, and a negative relationship between hotel and allied staff, and output, indicating negative marginal product for this input. Medical support staff also exhibits negative marginal product. This input, together with the year of observation, is not statistically significant and therefore not a good indicator of production.

Tables 7.4 and 7.5 show that technical efficiency has not improved over time. The falling number of hospitals from 116 to 101 is a result of closures and amalgamations over the period, most of which occurred following a period of inefficiency. It is notable that most of the closures observed occurred in regional Victoria where hospitals are smaller and cater to a smaller and more widespread population. Also, there is only one teaching hospital located in the non-metropolitan area, suggesting that the lack of teaching facilities in regional Victoria corresponds with a reduction in efficiency in those locations.

These results suggest that casemix funding benefits large metropolitan teaching hospitals, at the expense of small regional hospitals that are less capable of competing for government funding. The fact that casemix has been taken into account in this analysis suggests that hospitals have been compared on an equal footing. Nevertheless, geographical location, perhaps due to differences in concentration, population size, demographics, and hospitals’ limited access to the pool of highly skilled nursing and administration staff, appears to have had a significant impact on these results.

Chapter 8

Conclusion

The central aim of this thesis has been to analyse the Victorian public hospital sector and determine to what extent, if any, the introduction of casemix funding using DRGs has contributed to improved efficiency in that State's delivery of acute hospital services. In arriving at the conclusion that there does not appear to have been an improvement in individual hospitals' technical efficiency over time, it is still evident that casemix funding has altered the way that scarce resources (that is, government funding) are distributed to acute hospitals. Although this funding arrangement was originally designed, among other things, to improve efficiency in response to various reports on Victoria's acute health system, the evidence produced here shows that this objective was not completely realised. If, in fact, overall cost savings were achieved in Victoria, they were due to closures and amalgamations of small regional hospitals during the period. The evidence on economies of scale in the hospital sector supports this conclusion by providing a survivor analysis of Victorian public hospitals. In any event, the existence of increased health expenditures, coupled with evidence of growing waiting lists in Victoria, also casts doubt on whether the objective of increased efficiency was realised.

The literature that informs this thesis is varied and complex. Issues of implementing appropriate hospital reimbursement schemes, and their impact on the adoption of new technology, patient mix and treatment options, afford a greater understanding of the drivers of adverse selection and moral hazard effects in healthcare. It is also apparent from the literature that both DEA and SFE techniques have been applied to health data elsewhere, and have been the subject of intense debate concerning their legitimacy in general, as well as in their application to healthcare. Clearly the importance of hospital funding to the provision of public health necessitates considerable scrutiny to ensure that efficiency measures provide policymakers with accurate information. The frontier techniques are examined generally in the literature to provide an understanding of their strengths and weaknesses. There also exists significant literature that addresses Australia's (and Victoria's) health sector and funding arrangements in place during the period of observation of this thesis; namely, the development of casemix funding using DRGs. Evidence is also provided on hospital merger activity resulting in increased concentration, and the resulting effect on competition and efficiency.

Three techniques are used in this thesis to examine acute public hospitals in Victoria and provide information on their scale and efficiency. Survivor analysis is used to reveal the optimum size of hospitals by calculating changes to market share for each size group over time. The strengths and weaknesses of this technique are outlined, along with a justification for its application to hospitals. DEA is a non-parametric frontier technique that was developed to envelope the data based on best results obtained in practice. DEA was the first method in the development of modern efficiency measurement, and this thesis provides a description of the assumptions behind the technique. Although DEA measures both technical and allocative efficiency, it is preferable to measure technical efficiency only since it avoids altering the production isoquant, which is a problem inherent in measuring allocative efficiency. Technical efficiency measurement does not require input price data and is less sensitive to the introduction of new observations. The third technique considered and outlined is the SFE. This thesis sets out the main characteristics of the technique, including the development of the fixed-effects and random-effects model with time-varying or constant technology. Its main advantage is that SFE is able to separate random noise from inefficiency through a decomposed error term. It has been shown that firms' operations are suboptimal and, therefore, analysis of production frontiers is more realistic than that of production functions. Also, the use of panel data provides richer results than cross-sectional data due to the data being broader.

The context within which Victorian health reforms were implemented is an important consideration in this thesis. The Australian healthcare sector provides both universal public health services under Medicare, together with voluntary private health insurance. This creates strong demand for public hospitals as even privately insured patients may elect to receive treatment as public patients in public hospitals. Health funding arrangements in Australia contain both Federal and State elements, leading to issues of vertical fiscal imbalance and Constitutional conflict. The application of

DRGs in casemix funding has allowed efficiency comparisons of public hospitals, such that funding can now be directed to those hospitals that show efficiency improvements, and away from those that do not. This new arrangement in the funding process was made necessary due to excessive State debt, in particular in Victoria, and spiralling health costs in general. Health reforms in Victoria were thus driven by a combination of the reported inefficient delivery of acute health services and spiralling government debt. AN-DRGs were modelled on the U.S. version of DRG weights initially but were later modified to better reflect Australian casemix.

Hospital waiting lists received considerable attention in the form of throughput targets being met with financial incentives. However, the early unexpected success of increased throughput resulted in greater than expected demand on these funds. Subsequently, the Victorian government imposed a limit to accessing throughput funds, resulting in a return to increased waiting lists, bed closures and staff reductions. Evidence shows that the combination of budget caps and waiting list targets clearly act to counter each other, leading to a reduction in Category One and Two patients on Victorian waiting lists, but an increase of Category Three patients. There is also evidence presented that total health expenditure in Victoria decreased initially, following the implementation of casemix funding, but then increased at a faster rate after 1995/96. At this point in time it is clear that Victoria provided less public hospital beds per 1000 population relative to the other States and Territories, suggesting that the increase in total health expenditure was not directed to this area.

The application of survivor analysis to private and public hospitals in Victoria and Australia shows that economies of scale exist, especially in hospitals with less than 50 beds. This is evidenced by decreasing market share over time, as well as by the number of closures and amalgamations among this group. In Victoria the smallest hospitals are situated in rural regions, and so these results suggest that the change to an output based funding system, such as casemix funding, had the effect of reducing their market share.

The DEA models derive a frontier from the data, and so it appears that some hospitals are technically efficient and continue to be so over time. The graphs of frontiers using this method show that hospitals appear to improve efficiency slightly over the four year period, although not by any significant amount. Results obtained using SFE show no improvement over time; however the inefficiency effects model shows that hospitals in the metropolitan area and teaching hospitals reduce the inefficiency effect. Table 6.1 shows the results obtained from DEA under the assumption of constant returns to scale. These results show that teaching hospitals were more closely aligned with each other at the beginning of the period than were the other groups, but some teaching hospitals achieved higher technical efficiency scores toward the end of the period for WIES but not necessarily for acute separations. Graphs in Appendix 1 illustrate that the majority of hospitals marginally improve their technical efficiency score over time with a south-westerly shift of frontiers. The DEA model based on Banker, Charnes and Cooper (1984) accounts for variable returns to scale and generates scale efficiency results in addition to constant returns to scale scores. These results group all hospitals together in Table 6.2 and show that there has been an improvement overall in technical efficiency scores, especially under the assumption of variable returns to scale. Scale efficiencies have improved, with fewer hospitals in the lower performing group at the end of the period.

An important point when interpreting results using DEA models is that these frontiers have been derived from the data. They do not represent an *ideal* combination of inputs to produce outputs, merely the best combination, given the data. Improvements over time are shown by, both, a grouping of data points closer to the efficient frontier in the graphs (Appendices 1 and 5.3), and a movement in the frontier. In the former case, using DEA methods does not provide information on absolute improvements, merely relative improvements in technical efficiency scores. Frontier movements are only apparent visually from the graphs, and these are only slightly so.

The parametric results obtained from the SFE model using panel data show the absence of any improvement in technical efficiency scores over time. The inefficiency effects model shows that there is a strong relationship between geographical location and efficiency, and type of hospital and efficiency. Observation of the technical efficiency scores of hospitals prior to closure or amalgamation (Table 7.5) shows that these hospitals, for the most part, experienced very low scores, were situated in regional Victoria and none of them was a teaching hospital.

The fact that the SFE model estimates the frontier from the data suggests that realistically hospitals have performed, at best, within 10 percent of achieving a position on the frontier. Continued cutbacks and expectations of efficiency improvements do not appear to be justified under this scenario since there does not appear to have been any significant improvement in efficiency in individual Victorian public hospitals following casemix funding. Cost savings, if any, are a direct result of closures and amalgamations that occurred in regional Victoria among small hospitals that were experiencing increasing returns to scale, but that were unable to expand due to the limited size of population and, consequently, their patient base, and lack of available doctors. In these circumstances, therefore, casemix funding using DRGs has not delivered the improvements that it promised, and future research should be directed at using SFE with panel data to analyse the implication of casemix funding applications Australia-wide.

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