msa-ferndale

Secta Group

Research on the differential costs of providing health and social services in areas across Northern Ireland arising through Economies of Scale.

Final Report

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msa-ferndale
Secta Group

Health & Social Care Consulting & Research

Belfast
393 Shore Rd
Whiteabbey
Belfast, BT37 9SB

Tel: 02890 369366

Newport
1 Lower Bar
Newport, Shropshire,
TF10 7BE

Tel: 01952 811777

London
87-91 Newman St
London W1T 3EY

Tel: 0207 323 7110

Birmingham
145 Great Charles St
Birmingham
B3 3HN

Tel: 0121 233 3000

Manchester
Parkway House
Palatine Road
Northenden, M22 4DB

Tel: 0161 902 1100

Wakefield
7 Lakeside
Calder Island Way
Wakefield, WF2 7AW

Tel: 01924 433433

Southampton
Shelly Lane,
Ower, Nr Romsey
S'hampton, SO51 6AS

Tel: 03280 813865

Glasgow
Tribune Court
2 Roman Road
Glasgow, G61 2SW

Tel: 0141 943 1800

Dublin
44 Fitzwilliam Place
Dublin 2

Tel: 01 676 9916

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PARTNERS FOR CHANGE

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Executive Summary

The Department of Health, Social Services & Public Safety in Northern Ireland (DHSSPS) commissioned *Secta MSA Ferndale* to undertake a research to explore the existence and nature of differences in revenue costs of providing health and social services between the four Health & Social Services (HSS) Boards arising from economies of scale.

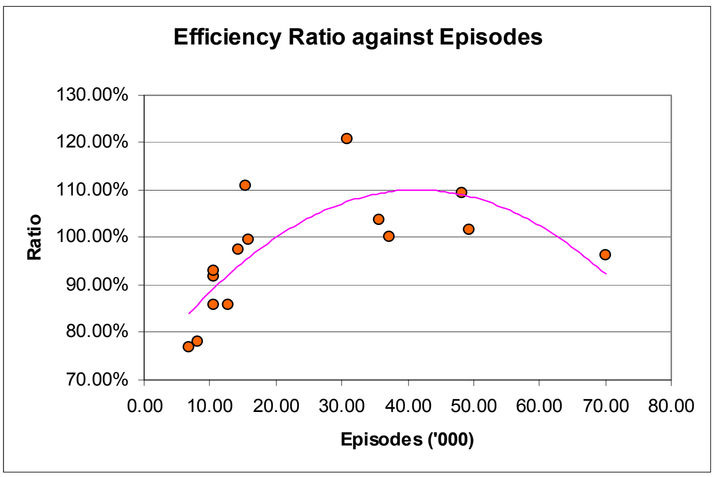
The study is intended to contribute directly to the ongoing development of the system for revenue resource distribution to the HSS Boards. It provides an evidence base in support of a formula adjustment to recognise and compensate for such additional and unavoidable costs, and identifies further work required.

Hospital Services

The aim of this analysis has been to estimate the expected costs of NI hospitals by deriving an HRG-based reference cost for each patient (inpatient and day case) and also estimating the excess bed day costs for inpatients who stay longer than the NI trim value of stay. In addition expected critical care costs have been estimated. Expected costs per episode can then be compared to actual costs per episode, to identify scale effects on costs.

A significant amount of effort and time was expended in ensuring, as far as possible, that activity and costs were matched each set of hospitals in the analysis. We are grateful to those who contributed to this exercise.

The results, expressed as a ration of expected to actual episode costs is shown below for all hospital groups in the analysis.



Whilst there was debate about the precise functional form of the scale relationship – due to the influence of the Royal Group – the Steerage Group decided to accept the results at face value as the basis of calculating scale cost budgets.

The relationships were applied to a number of configuration scenarios, and accounting for cross boundary flows.

<u>Current hospital configuration.</u>

When the scale cost are estimated for the current acute configuration, the total is £35.69m (to 2 d.p.). The table below compares the distribution of this funding – compared to normal Capitation shares for these funds.

Board	Scale Budget	Capitation Shares
Eastern	£15,913,273	£15,046,064
Northern	£10,209,306	£8,443,783
Southern	£4,786,285	£6,306,071
Western	£4,779,145	£5,892,090
Total	**£35,688,009**	**£35,688,009**

The results imply similar funding for the Eastern Board but increased funding for the Northern Board. It would lead to reduced funding for the Southern and Western Boards.

In this analysis the very high value estimated for the diseconomy of scale associated with the operations of a very large hospital is a dominating influence. However, it is unclear whether the identified scale-related costs of the current operations of the hospital service are a valid pointer to the existence or otherwise of unavoidable scale costs associated with providing efficient hospital services in areas of different population and population settlement patterns.

In order to throw further light on this question a more theoretical approach has been taken to the provision of a balanced hospital service.

<u>Theoretical hospital configuration</u>

A three level acute configuration for Northern Ireland was developed where the number and spatial distribution of units was optimised to meet agreed access and volume rules applied at LGD level. This provided a way of determining the 'unavoidable' consequences of scale where size is driven by population-based need rather that historic policy.

Two alternative assumptions regarding travel time were used (SMOSS & Congestion) – and two sets of results are presented below.

Access Scenarios				
	Congestion	**Share**	**SMOSS**	**Share**
Eastern	£6,195,823	30.97%	£5,762,414	30.19%
Northern	£4,508,536	22.54%	£5,117,107	26.81%
Southern	£4,239,497	21.19%	£3,740,160	19.59%
Western	£5,059,539	25.29%	£4,469,923	23.42%
	£20,003,395		**£19,089,604**	

It can be noted that the total cost, in both cases, is significantly below the figure for the current pattern of service - £35.69 million. This is, without doubt, largely the result of the scale-cost minimisation procedures used in the access modelling in the Belfast area and achieved by restricting the maximum allowable hospital size.

The exercise was repeated for the configuration envisaged under Developing Better Services. This is presented in an Appendix to this report.

Community Services

The main component of 'scale' in community services that has been studied relates to staffing levels. The hypothesis explored is that operational units might have differential staffing levels in areas having different population settlement patterns and, in particular access requirement might lead to team sizes that are unavoidably constrained in size, leading to scale-related extra costs. The following community services have been investigated:

- District Nursing;
- Health Visiting;
- Day Centre Services;
- Child Care Social Work;
- Home Care;
- Occupational Therapy;
- Community Psychiatric Nursing;
- Community Midwifery; and
- Emergency Ambulances.

The approach used has been:

- first to determine the optimal locations of services to meet accession rules (consistent with the Capitation Formula adjustment for rurality);

- then to model the delivery of services, noting the scale effects arising from the staff capacity required to respond to unpredictable variability in demand to agreed performance standards.

The findings from the study of these services have also been used to extrapolate likely scale costs to other similar services that have not been studied in detail.

The results for all community services (modelled plus extrapolation) are set out below – again under travel time assumptions SMOSS and Congestion.

Board	Scale Cost SMOSS	Share	Scale Cost Congestion	Share
Eastern	£4,399,860	32.39%	£4,627,185	32.54%
Northern	£3,867,560	28.47%	£4,083,641	28.72%
Southern	£2,619,168	19.28%	£2,731,318	19.21%
Western	£2,695,985	19.85%	£2,777,343	19.53%
Totals	**£13,582,572**		**£14,219,486**	

Conclusion

This research has broken new ground both in developing and applying an appropriate methodology to cast light on scale in health and case delivery.

A modelling approach has been applied to theoretical configurations of service with the main aim of identifying scale effects that might inevitably result from applying consistent access requirements in areas with different geodemographic characteristics in Northern Ireland. In general the findings provide support (both theoretical and empirical) for the existence of such scale-cost effects.

On the hospital side of the work, the research has identified scale effects but of a complex nature. It does appear that small hospitals might well face unavoidable difficulties in achieving the cost efficiency levels that they would wish to achieve but, on the other hand, large hospitals might also face extra costs that are not adequately reflected by reference costing methods.

On the community side of the work the research has delivered findings that reflect the working through of plausible assumptions concerning staffing/manning level effects in teams of differing sizes under conditions of demand variability.

The research has reached the point where scale cost budgets can be considered and via top-slicing methods applied to funding mechanisms. Further research on some aspects is recommended and proposals for such are set out in the report.

CHAPTER 1:
Introduction

The Department of Health, Social Services & Public Safety in Northern Ireland (DHSSPS) commissioned *Secta MSA Ferndale* to undertake a research study for the Capitation Formula Review Group (CFRG). In particular, to explore the existence and nature of differences in revenue costs of providing health and social services between the four Health & Social Services (HSS) Boards arising from economies of scale.

The study is intended to contribute directly to the ongoing development of the system for revenue resource distribution to the HSS Boards. It aims to provide the evidence base in support of a formula adjustment to recognise and compensate for such additional and unavoidable costs, if and where appropriate.

This report sets out the detail of the research undertaken, and the findings and recommendations reached.

Background

The DHSSPS and the four HSS Boards in Northern Ireland have been engaged in a rolling programme of work since 1994 aimed at improving the weighted capitation formula for revenue resource to HSS Boards. Prior to this, allocations were made using the old Proposals for the Allocation of Revenue Resources (PARR) formula - itself derived from earlier work by the Resource Allocation Working Party (RAWP) in England.

The programme of work is being taken forward by the Capitation Formula Review Group, which comprises a multi-disciplinary team drawn from the Department and Boards. The CFRG's terms of reference are:

"…to ensure that the resource allocation formula, for use in the distribution of resources to Board level, provides the best measure of relative need for health and social care in Northern Ireland"

The aim of the CFRG research programme is, therefore, to ensure that as far as possible the allocation mechanisms (usually expressed as formulae) are consistent with the 'fair shares' principle. This principle requires funding distribution to take account of:

- relative differences in the levels of need within each Board's population for relevant health and social care programmes; and

- *legitimate differences in the unavoidable costliness of providing services to meet that need,* ceterus paribus.

In *A Third Report of the Capitation Formula Review Group* (DHSSPS, 2000), the CFRG set out the very significant progress made in developing formulae for each of the nine Programmes of Care (POCs) in Northern Ireland. The formulae for each Programme contains adjustments in respect of:

- the relative needs of different age and gender sections of the general population - and the resulting impact on per-capita costs of provision; and
- the additional per-capita costs arising from factors known to be linked with variations in levels of need from particular individuals or communities – such as low birth weight or deprivation.

In addition, an adjustment is applied to each Board's initial share according to their proportion of a 'rurality budget'. This budget is intended to reflect the additional costliness of providing community-based services in rural areas, where relatively more time and cost is incurred in travelling.

However, the Third Report recognises that a further factor may also affect costliness for hospital and community services between communities across Northern Ireland that live in service catchment areas of different sizes. This is the issue of revenue cost economies (or diseconomies) arising through achievable scale and scope of service delivery.

MSA Ferndale undertook a brief exploration of this issue in earlier work to develop the rurality adjustment described above. The Third Report recognises, however, that:

> "*The analysis of procedure cost and trust size would not have been able to identify any variation between facilities within a trust (it was at trust level that the contracting information was readily available). In addition, the research team itself acknowledged the limited nature of the analysis…No attempt was made to identify the potential impact of economies/diseconomies of scale associated with the provision of services in rural versus urban areas*."

The Third Report concludes that:

> *"more detailed research should be undertaken to establish the impact of economies/diseconomies of scale on the cost of providing Hospital, Community and Personal Social Services in urban and rural areas"*

This report sets out the results of such a research study.

Terms of Reference

This study aims to:

- establish the existence, nature and extent of economies of scale and scope effects on the revenue costs of providing hospital and community-based health services (HCHS) and personal social services (PSS) in Northern Ireland;

- establish how this effect differs between administrative and service catchment areas across Northern Ireland – in urban and rural areas for instance;

- quantify such effects, and derive therefrom, an index of relative costliness arising from these issues alone that could be applied to compensate Health & Personal Social Services (HPSS) commissioners for such legitimate and unavoidable cost differences; and

- make appropriate recommendations to the CFRG.

The remainder of this report sets out the investigation undertaken, data collected and analysed, and results obtained.

CHAPTER 2:
Hypotheses & Research Design

This chapter describes:

- introduction to the nature of economy of scale effects;
- evidence of economies of scale from the published literature;
- introduction to the SMOSS-based modelling approach utilised within the research;
- introduction to the particular economy of scale effects for Community Services; and
- a list of the hospital and community services explored in detail in the study.

Introduction to the Nature of Economy of Scale Effects

The notion of economies of scale (EoS) generally relates to the possibility of reducing unit costs by increasing volumes of activity within organisations, i.e. part of the quest for increased efficiency. Exploiting EoS effects can often be an important driver towards increasing organisational size and/or increasing centralisation of activities. The classic example from industry is Henry Ford's introduction of the production line, which revolutionised the unit cost of producing cars.

Pressures for increased efficiency of operation are also relevant in the public sector, leading towards a desire for increased organisational size, greater centralisation of services, increased sharing of scarce resources, increased sharing of information, and so on. However, in practice, it is recognised that, whether in the public or private sector, EoS benefits will often be counterbalanced by potential difficulties. Examples of these include reduced accessibility to services by local populations, increased complexity of larger organisations (and potential diseconomies of scale), loss of autonomy and flexibility of organisational units, and so on.

The particular aim of this project has been to explore the balancing of two such effects within the health and social service sector – namely, balancing the potential EoS cost benefits of larger organisational units against the unavoidable requirement to provide acceptable levels of accessibility to services by local populations. It has been accepted that, from the point of view of the service user, locally available services if they are of appropriate capability and quality, are most desirable. The inconvenience and anxiety generated by services provided 'at a distance' is well recognised and will often be sufficient to deter users from taking up the services at all – the research-based empirical support for this assertion is considerable. Also, there is a lot of evidence in the research literature that distances and journey times will also often deter providers from providing services to inconveniently located communities for resource reasons.

On the other hand, scale effects are also well recognised. In Northern Ireland, for example, small hospitals have been (and continue to be) found 'unsustainable' because the costs of operating them at required levels of service effectiveness and quality are too high. For example, appropriate equipment and technology cannot be justified, appropriately qualified staff cannot be 'attracted', required covering arrangements for key staff cannot be organised, and so on. There are also strong indications that for some conditions and procedures very low volumes can be associated with higher risk.

Funding Implications

The objective of this project in the context of funding deliberations has been to develop funding mechanisms that support a balanced approach to service provision – i.e. to support services that exhibit accessibility and yet exploit possible (i.e. achievable) scale-related cost efficiencies. In particular, the aim has been to avoid any approach that could, at the extremes, either unduly heighten pressures towards centralisation (mainly in the Belfast area) or encourage highly dispersed and cost inefficient services.

Thus, there are two key questions that have been asked in the analysis of the various services, vis:

- what is the minimum service specification required to meet reasonable access requirements for the service being considered? and
- what EoS effects are present within such a service specification?

Access Requirements

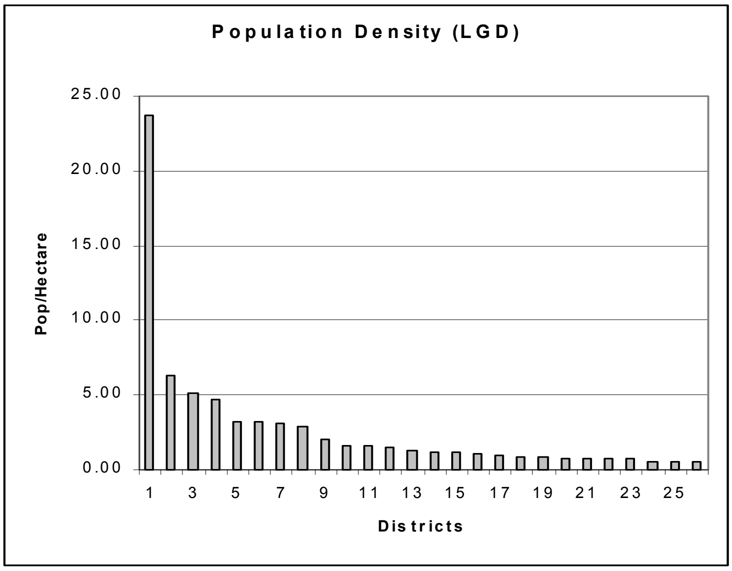
An important assumption of the project is that, in terms of accessibility, services should be provided as much as possible in a reasonably fair and equitable way to all members of the community. This aim is particularly relevant in Northern Ireland with its low overall population density and the high concentration of population in the Belfast area. These characteristics can give rise to very great pressures towards the centralisation of services in the Belfast conurbation and great pressures on service sustainability in areas outside Belfast.

In order to set reasonable equability criteria for the communities across Northern Ireland, a Local Government District (LGD) approach was agreed with the Project Steering Group. As far as possible the communities in each District have been given equal consideration and, although these Districts may not necessarily be 'natural' communities, they provide a workable approximation to such.

Overall, Northern Ireland is amongst the most sparsely populated areas of the UK, with around 1.54 persons per hectare. There is one major conurbation – Belfast – and circa 36 other principal urban centres of population. Generally, population sparsity increases as we move westwards, although there are also areas of low population density in both the north and south of the region. Administratively, for most health and social services, Northern Ireland is organised into four 'Board' areas – North, South, East and West with the Eastern Board being almost five times as densely populated as the Western Board on average.

Recently, however, moves are being made to change from this Board structure to one based on combinations of the 26 Local Government Districts. These Districts also vary in their population densities as shown in Figure 2.1.

Fig. 2.1: Population Density for Local Government Districts in NI



Both at Board level and at District level these variations in population density have significant implications health and social care delivery when region-wide accessibility standards are applied.

Approach to Modelling Service Configurations

The ultimate aim of this project has been to determine any funding implementations for the HSS Boards associated with their unavoidable attempts to balance scale and access. Hence, the research requirement has been the quantification of the EoS costs faced by the various Boards due to their unique population distribution characteristics.

The costs from the modelling undertaken in this study are economic costs and they reflect an assessment of an important component of the relative resources needed by Boards in their endeavours to achieve reasonable and fair access targets and long term sustainability. This is predicated on the assumption that funding should support these endeavours and be a positive mechanism for worthwhile change. The analysis has not been concerned to evaluate the adequacy or otherwise of the overall quantum of resources available for the provision of the selected services in Northern Ireland.

There is no reason to suppose that the current configuration of services in Northern Ireland is necessarily 'optimal' in terms of both economic efficiency and access to services. No evidence exists to support the view that the optimal balance has already been struck between access and sustainability. Therefore, for funding to merely reflect the costs of current arrangements would bring with it the danger of reinforcing current inefficiencies. Hence, it has been essential to pursue a modelling approach capable of evaluating alternative service configuration scenarios. This adds considerable strength and insight to the study, enabling both existing service configurations and optimal service configurations to be examined side-by-side where appropriate.

The service configuration models developed are highly flexible, and any configuration of service provision (including the current configuration) can be tested in terms of its access performance and EoS effects. In practice, the emphasis within this project has been on the evaluation of 'optimum service configurations' – i.e. configurations that minimise resources whilst being capable of meeting access requirements set by the Project Steering Group.

An overview of the general approach for a particular service would be:

- agree an access criteria for the service - for example, 95% of each LGD's population to be within 30 minutes driving from a local hospital;

- use the Excel-based "access model" developed for this study to determine the minimum number and location of centres required to meet the access criteria. These models use data from previous studies for DHSSPS on the travel times from every Enumeration District (ED) in Northern Ireland to every feasible service location. [N.B *EDs are official Census enumeration boundaries below Ward level - there are*

3,729 EDs in Northern Ireland. Feasible service locations vary with the type of service being considered - for example 37 urban centres are considered feasible for the location of a hospital service, though clearly no scenario would arise where all 37 are used].

In this study, two types of travel times have been used – "SMOSS Default" and "Congestion Weighted". [*N.B. SMOSS stands for Simplified Modelling of Spatial Systems, and refers to a technique for spatial analysis and accompanying datasets developed for DHSSPS as part of an earlier research project by Hindle and Spollen*[1]]. The latter travel times are adjusted for population density (i.e. travel times are assumed to be greater in built-up areas). The result of using Congestion Weighted travel times is that more locations may be required to meet access criteria in urban areas. The final set of locations constitutes the optimum service specification for the service and the access model gives the population attracted to each location.

- Estimate the activity at each location for this service specification. Average demand levels for Northern Ireland have been used to calculate activity levels based on the attracted population.

- Quantify and cost the EoS effect for the service.

- Aggregate results to board level taking into account cross-boundary flows (i.e. people whose nearest location is in a neighbouring board).

EoS Effects in the Provision of Community Services

<u>Possible EoS Effects</u>

There are three possible aspects of community services which might be relevant to an examination of EoS, vis:

(a) the size of offices / facilities used;
(b) the size of the operating teams; and
(c) the population distribution (rurality) of the areas served.

a. Unlike hospitals, community services tend to utilise small-scale facilities and, furthermore, these facilities are normally shared with other services. For example, district nurses will operate out of health centres that are shared with general practitioners, health visitors, practice nurses, etc. Because these facilities are both small and often shared, it has not been thought appropriate to explore economy of scale effects for community service facilities. The only exception to this is in relation to day centres, which are relatively specialised and often reasonably large.

b. Within Northern Ireland there are a variety of sizes of operational teams such as district nursing teams, home care worker teams, manned vehicles operating from day centres and so on. The EoS effect relevant to size of operational team is mainly related to staffing requirements. This is because staffing requirements are affected by the need for the operating team to respond to a workload that varies on a day-to-day basis.

   Variability of demand or workload is a well-recognised economy of scale effect – this is because small teams find it more difficult to operate efficiently than larger teams when faced with variability in workload. Often in the public sector staffing levels are set on an overall expected workload basis – per client, per head of need-weighted catchment populations etc. – an approach which may fail to fully recognise the costs arising because of these scale effects.

   It is important to note that community services differ in their requirement to deal with variability in demand. Some demand can easily be scheduled into next week's diary, whereas some demand (for example, emergency ambulances) must be responded to that minute or day. Not all variability in demand therefore will be relevant to staffing levels. Thus, the EoS effect is only dependent upon variability in demand which must be responded to – this feature of a community service has been determined through the use of a questionnaire sent to all community services (see Appendix B for a copy of the questionnaire)

   The technical reason lying behind the EoS effect of workload variability is that, if any part of a service is subject to random daily variability, this will generally mean that the standard deviation (the operationally relevant measure of variability) of the process will be equal to the square root of the average level of workload. This is because if any demands for a service arise as random events in a period of working time they will follow the Poisson distribution. This distribution has the characteristic that the variance of the numbers of demands arriving within equal time units will be equal to the average numbers arriving. Hence the standard deviation will be equal to the square root of the average demand rate. This research has used this result to estimate the demand levels that can be expected on busier days than the average day – where the input number of standard deviations selected defines 'busyness'. For a simple treatment of this topic see, for example,' *Operations Research – Methods and Problems' by Sasieni, Yaspan and Friedman, Wiley, 1959.*

   Thus, if the average demand is 4 units of work the standard deviation will equal 2 units, whereas, if the average demand is 16 units of work the standard deviation will be 4 units. In both cases the statistical likelihood of workload being at least one standard deviation above the average value is the same but, in the former case, this represents a workload that is 50% greater than the average workload whereas in the latter case it is only 25% greater than the average workload.

c. Regarding the potential EoS effects of travel related activities, sparsely populated areas will often incur higher travel-related unit costs because of the longer inter-call travel times and distances involved. These cost differences are linked to the scale of operations because, in practice, it is often in the more rural areas that the smaller scale operations are to be found. *However, this effect has been excluded from this study because the DHSS&PS have already in place funding mechanisms that compensate for these costs in areas of different population sparsity*. In practice, great care has been taken in this study to ensure that the methods employed for evaluating EoS costs do not inadvertently include travel-related cost effects and, hence, to avoid any possibility of 'double-counting'.

The Organisation of Services

For the reasons discussed above, the assessment of EoS effects for community services has focussed mainly on the sizes of operational teams in terms of staffing levels. Hence, it is important to understand why such units do differ in size and why such differences are unavoidable.

The main reason is that the services do need to be accessible to the clients served. Even though generally the services are provided by travelling *out* to the clients rather than the clients travelling *in*, there are a number of reasons why service units cannot operate effectively and efficiently over large geographical areas. Examples include:

- the emergency ambulance service sets response time targets such that incidents can be reached if within given travelling times;
- clients travelling on day centre vehicles, for gathering and return journeys, should not face 'in transit' times that are unacceptable;
- Home Visiting services such as district nursing often need to visit individual clients more than once during the day on clinically determined schedules; and
- some services such as community psychiatric nursing are normally provided from bases that are starting and finishing points for daily tours of duty and the daily workloads will need to be feasible in light of this requirement.

These and other factors are reflected in the current organisation of community services on the ground in Northern Ireland. The services provided can be observed to operate within quite clearly defined operating areas (catchment areas, patches, and so on) in such a way that accessibility considerations are taken into account. Thus, in sparsely populated areas, team sizes tend to be smaller than in more urban areas and overall daily workloads tend to be lower. For example, the emergency ambulances operating in the Enniskillen area can expect only around eight incidents per day - whereas those operating from the Craigavon base can expect around three times this number.

Although the balancing of accessibility and workload considerations is observable in the current organisation of services, as indicated earlier in this chapter, there is no reason to suppose that the current configuration of community services in Northern Ireland is necessarily 'optimal'. Since the aim of this project is to highlight *unavoidable* EoS effects, the methodology employed has endeavoured to simulate 'best possible' patterns of deployment. This has involved pre-defining the accessibility and workload volume criteria for each service studied and minimising the number of operating areas required meeting these requirements. These issues and their consequences are explored in later chapters.

Services selected for this study

The Project Steering Group, in collaboration with the research team, resolved on the following services to be tested for economy of scale effects.

- Hospital Study - Services at:
  – current operational locations for main acute services;
  – locations determined through the process as 'optimal' from an access and volume perspective; and
  – the locations envisaged under *Developing Better Services* proposals.

- Community Services Study:
  – District Nursing
  – Day Centres
  – Social Work (Family & Child Care)
  – Emergency Ambulances
  – Health Visiting
  – Home Help
  – Occupational Therapy
  – Community Midwives
  – Community Psychiatric Nursing

The above community services were selected from a longer list because these services:

- present a range of attributes that are likely to expose the attendant costs of production to economy of scale-type influences;

- offer better quality and availability of information than alternative services having similar attributes;

- represent major areas of expenditure.

Although only the selected community services have been modelled in detail in the research, Chapter 8 explains how the results can be extrapolated to all like services to produce a total economy of scale budget for community services.

CHAPTER 3:
Economy of Scale Effects in Northern Ireland Hospitals

In this study, activities and costs in Northern Ireland hospitals have been explored:

(a) to determine (or otherwise) whether there is evidence for EoS scale effects in the operations of current hospitals;

(b) to identify and quantify such scale effects if they are present so that the relevant scale costs for hospitals of different sizes can be estimated;

(c) to model a number of alternative hospital configurations or scenarios in terms of access, activities and flows with a view to estimating overall scale costs;

(d) to attribute the EoS costs derived from (c) to Districts and Boards taking account of expected patient flows to each hospital in each scenario.

This chapter deals with parts (a) and (b). The next chapter examines the implications of the modelling for the current hospital service, the following chapter develops a number of alternative hospital configurations and the final chapter deals with the overall implications of the EoS evaluations of the various scenarios.

Introduction

Previous research

The King's Fund study, *Acute Futures* (1996) [1], discusses some of the opportunities for economies of scale in the acute hospital environment. These are:

- the scope for using expensive fixed assets such as operating theatres or diagnostic equipment more intensively in large hospitals;
- a minimum level of staffing may be required to provide certain services, and again the scope for making more efficient use of staff may be greater in larger hospitals;

- larger hospitals may require a smaller margin of reserve capacity to deal with variability in demand; and

- larger hospitals provide more opportunities for staff to specialise in specific functions, and this may also lead to greater efficiency and reduced costs.

The University of York (1997) [2,3] reviewed the wide body of published research concerning dis/economies of scale in the provision of hospital services. That review concluded that economies of scale are largely achieved for acute units in the region of 150-400 beds (around 9,000 to 25,000 inpatient episodes), and that diseconomies may reappear above this workload.

Quite a lot of research has been carried out in the USA. Spang *et al* (2001) [4] found that merging hospitals experienced slightly smaller growth in costs compared to non-merging rival hospitals in the USA over the period 1989-1997. The average size of hospitals before merger was 248.

"Where hospitals are characterised by excess capacity and unused facilities, concentration (or merger) may reduce overall unit costs by taking surplus capacity out of the system"

In contrast, Weil (2000) [5] concluded that over the last 25 years little operational and fiscal evidence had been published in the health or general management literature that indicates the efficacy of horizontal mergers. Another American study by Sinay (1998) [6] tested the existence of multiproduct scope and scale economies among merged and control hospitals prior to the merger and two years after the merger. This work showed that at an average size before merger of around 200 beds, there were significant economies of scale and of scope that were fully exploited after merger when the average size was 400 beds.

Dranove (1998) [7] estimated the magnitude of economies of scale in fourteen non-revenue-producing cost centres in hospitals – areas where one would expect to find most evidence of economies of scale (e.g. administration, medical records, laundry etc). He found that there were substantial economies of scale in smaller hospitals but economies were exhausted in hospitals with over 10,000 discharges annually. He concluded that increasing size beyond 10,000 discharges was unlikely to improve efficiency.

Yafchak (2000) [8] found that in the USA over the period 1989-1997, smaller non teaching hospitals increased their market share and that teaching hospitals provided little support for the benefits of size based on the similarity of market share by bed size over time. Regression analysis indicated that economies of scale had only recently begun to be observed at least for hospitals up to 500 beds.

A few studies in America have examined the particular situation of rural hospitals. In the USA the rate of closure of rural hospitals in the last two decades has exceeded that of urban hospitals. Rural hospitals had an average size of around 85 in 1991 with relatively low occupancy rates and economies of scale were found to be important for small rural hospitals particularly for those with fewer than 100 beds. In response some hospitals formed consortia in which resources such as physicians, services, administration etc were shared. Chan *et al* (1999) [9] estimated the effects on costs in 335 consortium participating rural hospitals. The cost per admission fell from $3,400 with no collaboration to a minimum at around a group size of 45 ($3,150) and then rose again as group size increased further.

In the UK, a study in this area was undertaken by MHA/ORH (1997) [10] for the Department of Health Resource Allocation Group in England, concentrating mainly on A&E provision. However, as part of this study, the research tested the hypothesis that rural health authorities needed to maintain a larger number of acute general hospitals operating at lower levels of efficiency than would otherwise be the case in the average health authority. The study concluded that there was little evidence to support this hypothesis.

Research by YHEC/MSA Ferndale (1999) [11] undertaken at the time of the rurality capitation work in Northern Ireland, failed to identify any significant variation in unit costs for acute elective procedures between 'large urban' and 'smaller rural' hospitals. However this research was very much a preliminary examination of the situation.

Perhaps the most directly relevant work to this current project is that carried out in support of the Arbuthnott Report in Scotland – Fair Shares for All [12]. This work was based on 48 hospitals, a sample that excluded hospitals with a combined day case and inpatient activity of less than 5,000 per annum and, in practice, ranged from 8,650 to 39,130 for this combined activity. Regression modelling was carried out using this combined activity as the single output indicator.

The approach taken was to explain the difference for each hospital between the actual cost of running the hospital and its 'expected' cost. The main factors assumed to contribute to expected cost were (a) the number of specialties covered by the hospital and (b) the overall case complexity of the hospital. A dummy variable was also introduced to reflect the distinction between mainland and island hospitals.

The complexity weights that were used were derived from the National Costing Exercise carried out in all Trusts in England in 1998.

The results showed that, for acute hospitals, the difference of expected minus actual costs – for total costs, medical costs and nursing costs – is significantly greater as actual activity volumes increase above the lower-bound value of 5,000 annual inpatient plus day case episodes.

Indicators of Hospital Casemix

One of the reasons for difficulties in establishing clear empirical relationships between hospital size and cost, despite the ready availability of data on hospital costs and activity, is that hospitals do differ greatly in the types of patients they treat. In particular, in the UK, there has been an absence of any agreed methods for assessing the inherent relative costliness – 'complexity' – of the caseload. Thus there are difficulties of comparing 'like with like'.

Even the extensive work on the development of casemix systems such as Diagnosis Related Groups (DRGs) and, in the UK, the development of Healthcare Resource Groups (HRGs), does not seem to have improved matters as much as might have been hoped.

One of the main purposes of DRG and HRG groupings is to enable patient episodes to be allocated to groups that are clinically homogeneous and that can be expected to use similar amounts of resources. However, in practice, there is a shortage of clear evidence that casemix systems successfully remove more than modest proportions of the observable variation in episode costs and there remains substantial 'within group' variations.

Nevertheless, despite these limitations, such casemix systems can be expected to control for resource use variability to some degree and the HRG system is regarded as being the most promising approach in this regard – at least in the UK.

<u>Data Sources</u>

Cost data by HRG have been published for some time in the NHS and are now also available in Northern Ireland but, in this case, only for <u>surgical specialties</u>, which cover only around 44% of total episodes. This relatively low HRG coverage in NI has meant that NHS data sources have been needed in this research to complement NI sources.

The data that have been made available for this research are as follows:

For Northern Ireland:

- the 2000/01 individual episodes for inpatients and day cases at each current hospital by specialty from the KEPS system (the DHSSPS Hospital Inpatient System);

- the 2000/2001 activity levels and expenditures for inpatients and day cases at each current hospital by specialty from the annual hospital summary accounts (Specialty Cost Returns); and

- the 2000/01 and 2001/02 HRG Reference Costs for inpatients (elective and non-elective separately) and day cases.

From England:

- the 2000/2001 NHS HRG Reference Costs for all specialties for inpatients and day cases (Department of Health, London);

- the 2000/2001 NHS Excess Bed Activity and Costs.

The major problem faced by the researchers was inconsistencies in activity levels recorded between the data sources in Northern Ireland. In particular the information on activity used in the Specialty Cost accounts was, in some cases, at variance with that found in the individual record database. In order to highlight and subsequently explain these differences preliminary models were built that allowed the potential scale effects of alternative data inputs to be studied.

Preliminary Work – Interactive Modelling

In order to explore, for possible scale effects, the hospital cost and activity information described above, an interactive 'what if' model was initially developed. This approach was also taken because of difficulties of reconciling the activity and cost data from different sources. The aim was to interact with members of the Steering Group and others in order to clarify the approach, the methods to be employed and, most especially, the relevant data inputs.

Overview of the Model

Casemix Weightings

The model allowed for five alternative casemix weighting options – two HRG-based schemes, a specialty cost-based approach, a length of stay weighting and a no-weighting option. In relation to HRG cost weightings, the coverage of the NI-specific HRG cost information is currently inadequate. These data limitations have meant that in relation to the use of HRG weightings, NHS cost weights are also needed. Two HRG-based weighting methods have been explored:

(a) Mixed weights – where NI weights have been used where available and NHS weights where these are not available. At this stage in the research an approximate method was used to obtain these weights.

Subsequently a more thorough approach was taken – described later.

(b) NHS weights only.

The former approach has advantages of greater NI specificity but the latter has the advantage of greater internal consistency. The models also allowed the use of average specialty costs as a basis for weighting. Also they allowed for the possible incorporation of any 'extra' length of stay effects where hospitals have lengths of stay that are greater than the expected stays that are built into the HRG system.

Input Options

The User could select the weighting method as follows:

Weighting Method	
No Weighting	Just actual episodes and costs are used
HRG weights – NI weights for surgery and NHS weights for medical specialties	A combination of NI and NHS reference cost weights
HRG weights – NHS weights for all episodes	These have used the database of NHS Reference Costs
Specialty Cost Weights	This weighting uses the average costs for individual specialties in NI
Length of Stay Weights	Incorporates any 'extra' stay effects

In addition, within the interactive model, the user could select to include total hospital costs or choose to remove the effects of capital charges from these costs. The User could also choose to include all hospitals in NI or a selection of the main acute general hospitals, where the hospitals that could be 'excluded' were specialised (or narrowly focused) with regard to their acute work in one way or another. The user could choose to include day cases or exclude them and could choose whether or not to include extra stay as well as (i.e., as a multiplier of) the selected weighting.

Findings

The model was interactive and generated a very large number of 'results'. A number of examples are shown below.

Figures 3.1 and 3.2 show outputs for the main acute hospitals, using the activity and cost data in the Specialty Cost accounts, for the two main HRG weighting schemes – NHS_HRG only and NI_NHS_Mixed_HRG. The activity basis used was the combined day case and inpatient activity. The charts show the estimated unit costs per casemix-weighted volume against weighted volumes.

Figure 3.1: Preliminary Findings NHS_HRG Weights

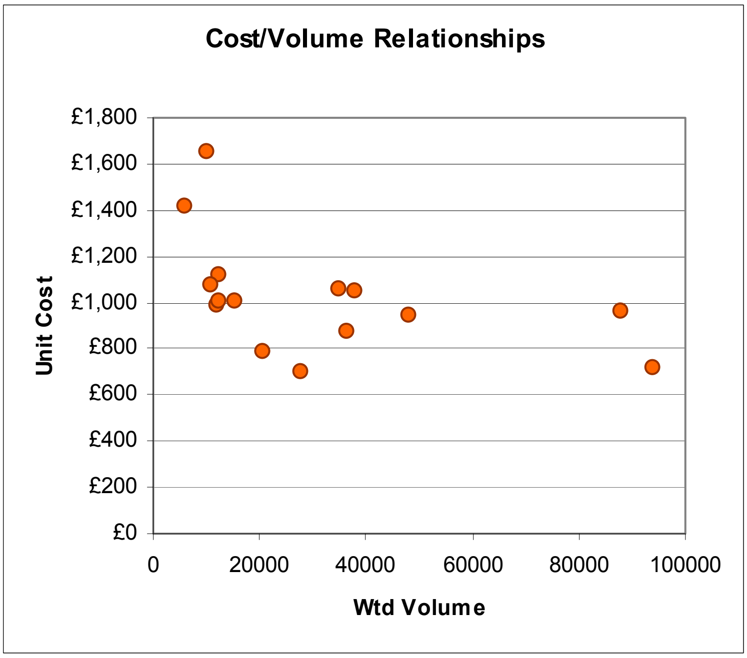
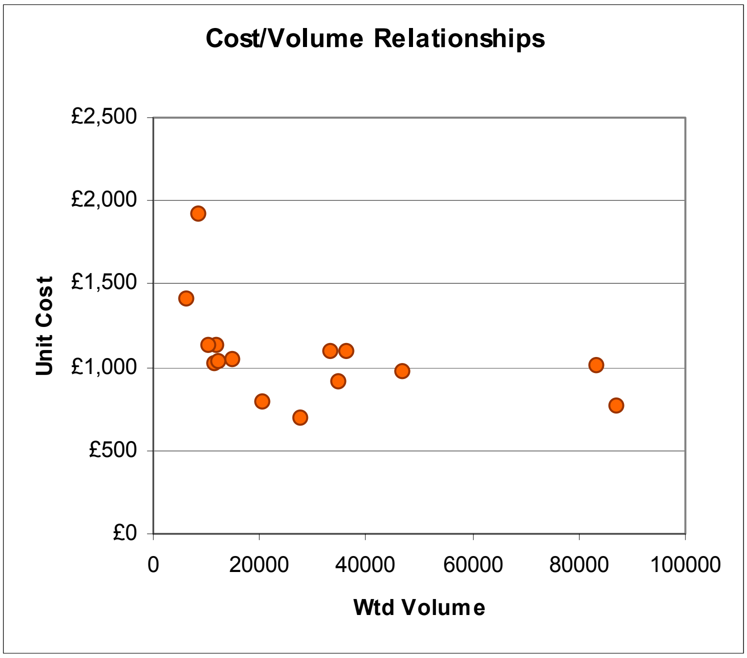


Figure 3.2: Preliminary Findings – NHS/NI Mixed HRG Weights



The above charts suggested possible scale effects and both HRG weighting schemes showed a similar, although not identical pattern.

Overall, the conclusion from this preliminary analysis was that a more thorough investigation should be carried out. It was eventually decided that the mixed HRG Weighting approach should be taken. It was also decided that the detailed individual episode database should be used both to assess the true levels of relevant activity and to provide HRG 'expected' costs and the expected costs of bed days above so-called trim values of length of stay.

Analysing the Expected Costs in NI Hospitals

The aim of this analysis has been to estimate the expected costs of NI hospitals by deriving an HRG-based reference cost for each patient (inpatient and day case) and also estimating the excess bed day costs for inpatients who stay longer than the NI trim value of stay. In addition expected critical care costs have been estimated.

The Episode Database

The following fields were extracted from the individual episode system for the year in question for all hospitals:

- Hospital Name
- Specialty
- Patient Designation (Private, NHS etc)
- Admission (Inpatient, Day Case)
- Type of Admission (Emergency, Elective etc)
- Episode Stay Duration (Days)
- HRG Code
- Principal Diagnosis Code

The database in total contains around 500,000 records. The records have been extracted to Excel files for twenty-two main hospitals. The names of the hospitals and the total number of records are shown in Table 3.1.

Table 3.1: The Selected Hospitals

Name of Hospital	Number of entries
Altnagelvin	41,467
Antrim	34,490
Coleraine	8,984
Route	6,826
Craigavon	37,417
Daisy Hill	17,998
Downe	7,452
Erne	12,952
Lagan Valley	11,784
Mater	16,665
Mid Ulster	11,442
Tyrone County	10,825
Ulster	44,992
Ards	6,595
Bangor	501
Whiteabbey	8,179
Belfast City	47,497
Belvoir Park	7,060
Royal Victoria	55,189
RBHSC	11,725
Royal Maternity	11,201
South Tyrone	5,633
Total	**416,874**

Developing the Costed Hospital Files

The Main Steps

The first step in this development was as follows: for each hospital for which an Excel file was extracted, each record was augmented using a number of Lookup Tables obtained from both NHS and NI Reference Cost sources.

Because not all specialties have been costed using the HRG system, episodes have had to be assigned a reference cost using a mix of NHS reference costs and NI reference costs. For the set of hospitals the proportion of records that could be costed using the NI HRG costs was 44.26% but this proportion varies widely between hospitals – from 0% (Bangor) to 61.4% (Lagan Valley).

The basic principal adopted has been to assign the NI reference cost where this is available and the NHS cost where this is not. However the

NHS cost was also assigned to all episodes where the NI cost is available. The aim of this process has been to allow a direct comparison of the two sources for any aggregations of episodes by hospital, specialty and so on. This aspect will be described in more detail later in this chapter.

The second step has made use of the 'Excess Bed Days' download from the NHS Reference Cost site. This provides a Lookup Table that gives for each HRG the expected proportions of excess bed days to total bed days for both elective and non-elective inpatients. This table allows an expected number of excess days to be assigned to each record using the relationship:

Proportional Excess Days = Excess Days/ (Excess Days + Non-Trimmed Days)

Although this indicator does not directly reflect what has actually happened to any individual episode, it nevertheless provides a reasonably unbiased estimate for any aggregated set of patients of the total excess days to be expected.

In addition the actual number of excess days for any individual patient has been obtained from the difference between the actual recorded stay and the trim-point stay assigned (from an NI Lookup Table) to each patient record.

The final step has involved the aggregation of the results by specialty and by method of admission – day case, elective inpatient and non-elective inpatient.

<u>Episode Groupings</u>

Each hospital cost file contains four episode groupings – two of which are manipulated in the way described above – an HRG coded file and a non-coded file.

The remaining files are firstly the private patient records and secondly any excluded records. Private patients have not been costed or analysed in any way other than by noting the numbers of records involved for each hospital. All episodes that are not either day cases or inpatients have been excluded from any further analysis.

The HRG coded file is, for all hospitals, by far the largest – usually above 95% of all records. In order to cost the non-coded episodes (in any given hospital) the results from the HRG-coded analysis have been used to obtain the <u>average costs</u> per specialty for day cases (per case), elective and non-elective inpatients (per bed day) and this applied (again using Lookup functions) to each individual non-coded record.

Summary File

The main summary file provides for each of 70 specialties the following outputs:

- Day Case Count
- Day Case Cost
- Elective Count
- Elective Inpatient Cost
- Elective Non-Trimmed Days
- Elective Excess Days (Actual)
- Non-Elective Count
- Non-Elective Inpatient Cost
- Non-Elective Non-Trimmed Days
- Non-Elective Excess Days (Actual)
- Inpatient Expected Excess Days

These outputs are available for both coded and non-coded episodes. Also Private patients are counted for day cases and inpatients.

It should be noted that excess days are not costed within this individual record file. This costing (along with other analysis) is carried out at specialty level within the linked analysis model (called 'Selection Model. xls') that is described in the next section.

Developing the Analysis Models

The main purpose of these models (referred to as 'Selection Models') is to provide an output of the total expected cost for any selected hospital for which a costed file of records is available.

The total expected cost (not including critical care at this stage) is regarded as the sum of all costs that are appropriate to the HRG level of costing plus the expected cost (not the actual cost) of excess days. The model operates at the specialty level by taking in (by pasting) the summary outputs from the hospital 'costed' workbooks described in the previous section.

This model allows certain user inputs:

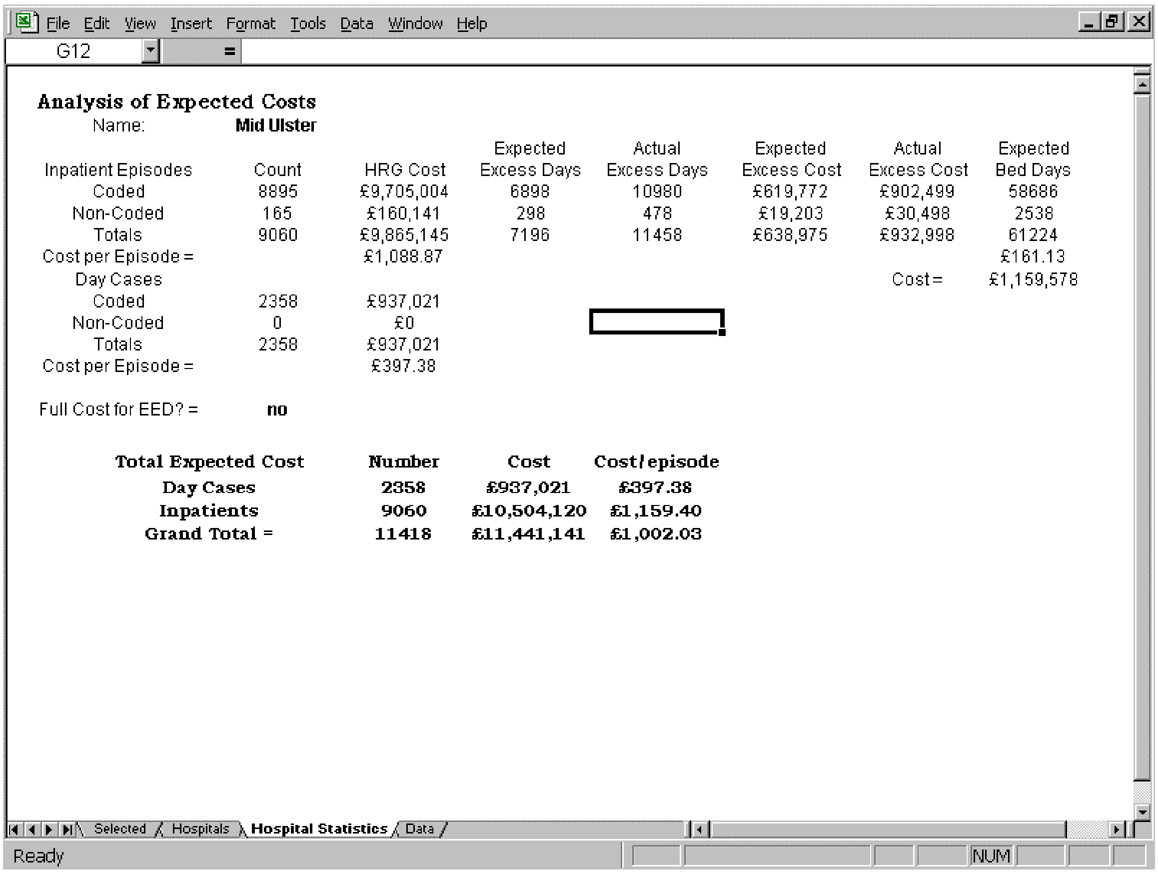
- whether or not a specialty should be included or excluded – either day cases or inpatients or both;

- whether excess days should costed at average expected bed day costs or at levels derived from an analysis of NHS trimmed versus excess day cost relativities (described later).

In order to describe this model it is helpful to show the output page and outline the way in which each component is derived. A picture of this sheet is shown in Figure 3.3.

The quantities shown in this illustration are influenced by the specialties selected and so should not be regarded as a final output for Mid Ulster.

Figure 3.3: An Example output screen from the Selection Model



Analysis of Expected Costs
Name: **Mid Ulster**

Inpatient Episodes	Count	HRG Cost	Expected Excess Days	Actual Excess Days	Expected Excess Cost	Actual Excess Cost	Expected Bed Days
Coded	8895	£9,705,004	6898	10980	£619,772	£902,499	58686
Non-Coded	165	£160,141	298	478	£19,203	£30,498	2538
Totals	9060	£9,865,145	7196	11458	£638,975	£932,998	61224
Cost per Episode =		£1,088.87					£161.13
Day Cases						Cost =	£1,159,578
Coded	2358	£937,021					
Non-Coded	0	£0					
Totals	2358	£937,021					
Cost per Episode =		£397.38					

Full Cost for EED? = **no**

Total Expected Cost	Number	Cost	Cost/episode
Day Cases	2358	£937,021	£397.38
Inpatients	9060	£10,504,120	£1,159.40
Grand Total =	11418	£11,441,141	£1,002.03

Notes on the various outputs:

1) The Name of the Hospital is obtained from the linked costed file
2) The episode counts can be seen to divide into HRG coded and non-coded and these totals will depend on the specialties that have been selected by the user. If all specialties are selected for both day case and inpatient episodes the counts will be totals for the hospital.
3) The HRG costs will be the sum of the relevant episode HRG reference costs from the costed file. However, these have been adjusted using a Lookup Table that contains for all costed hospitals the proportions of episodes costed using both NI and NHS reference costs and, for these matched sets the total uplift/down lift multiplier. This multiplier is then applied to the NHS only proportion of the cost. The reconciliation is only needed for episodes costed using NHS costs not for those costed using NI costs – it is those episodes that

are costed in both ways that provide the appropriate guidance on the multiplier for the hospital.

4) Excess costs are derived in two alternative ways via the check box. The first way uses the relative costs per specialty for electives and non-electives per bed day between trimmed and excess days obtained from the NHS Reference costing scheme. No similar outputs are available for Northern Ireland. The second method – indicated by selecting 'yes' in the check box – uses the total expected cost (not from the final table indicated in bold) divided by the total expected bed days and applies this cost to expected excess bed days. This approach essentially increases the expected costs in the final table because of the increase in expected excess day costs. (The theoretical justification for this approach is questionable as discussed later and it is not recommended by the researchers)
5) The two excess costs (actual and expected) are modified in the same way as in (3) above
6) There are three counts of bed days – actual excess bed days, expected excess days from the NHS Lookup Table and total bed days (the sum of actual non-trimmed and expected excess days). This approach assumes that actual trimmed bed days are a good estimator of expected trimmed bed days. This assumption is reasonable and, indeed, necessary, since no expected values of trimmed bed days per HRG (for electives and non-electives separately) are available from NI sources, because of the restricted range of specialties that have been 'costed'
7) Because the aim is to derive a reference (expected) cost for each hospital, actual excess bed costs are not directly incorporated in the computation of total costs but are provided here because the values might be relevant in subsequent interpretative work.

The final summary table (in bold) provides the key data needed for any cost weighting of the activities of the selected hospital – the overall expected unit cost per day case and per inpatient episode. Clearly, these unit costs are directly influenced by the specialty (and admission type) mix selected by the user in the 'selection sheet' provided in the model.

Estimating the Actual Relevant Costs and Activity in NI Hospitals

Analysis, described above, has been carried out in order to derive the total expected costs of selected NI hospitals for 2001 using the database of individual episodes for this year.

Expected cost is defined as the sum of HRG reference costs and HRG-related expected excess bed day costs. It has been important in relation to the project examining possible scale effects to also investigate the recorded costs of treating these episodes so that expected and actual costs could be compared.

The basic principle involved has been to try and identify in the Annual Specialty Costing Accounts (for 2001) the appropriate sets of episodes together with the costs recorded.

In practice, this has proved to be quite a difficult task involving a number of 'judgements', by the Steering Group and the researchers, along the way.

Modifications to Activities and Costs

For a variety of reasons, discussed below, certain activities and costs in the Specialty Cost Returns have needed to be modified - either being considered inappropriate and/or misleading and excluded, or 'missing' and added. This process was discussed and agreed with the Steering Group, and final data signed off by respective Boards.

Regular Attendance - Nephrology

In extracting information from the episode database for the expected costing exercise only day case and inpatient episodes have been retained. Hence regular attendees have not been included. The Nephrology specialty is dominated by regular attendance and because it is difficult in the Specialty Costing Returns to apportion costs between inpatients, day cases and attendees in this specialty this has required the exclusion of Nephrology costs from both the expected (by de-selecting the specialty using the Selection Model) and actual costing.

The results in terms of actual costs that have been excluded are shown in Table 3.2.

Table 3.2: Actual Costs for Nephrology in NI Hospitals

Name of Hospital	Day Case Cost	Inpatient Cost	In Expected Cost
Antrim	£1,915,886	£410,740	£1,366,107
Daisy Hill	£1,601,570		£400,978
Belfast City		£11,661,450	£4,542,239
Erne	£1,873,602		
RBHSC	£152,971	£433,858	£420,033
Total		**£18,050,077**	**£6,729,357**

The overall balance of costs between expected and actual in Table 3.2 indicates that around 41% of total Nephrology expenditure is coded as inpatient and day case activity (rather than regular attendance) in the hospital database. Clearly, however, it appears that admission type designation must vary widely between hospitals and, in these circumstances; it has been thought prudent to omit the costs in both cases (expected and actual).

Other Regular Attendance

Belfast City has a large number (4,824) of regular attendees associated with day case Dermatology at a recorded cost of £323,937. The hospital database shows two only day cases at an expected cost of £844. In this case it has been thought sensible to exclude the recorded cost and exclude day case activity and cost for this specialty from the 'expected' cost file.

A similar situation with regard to Dermatology occurs at Whiteabbey hospital at a recorded cost of £86,640. The hospital-costed file shows only 44 daycases at an expected cost of £17,730. Although this cost is a significant proportion of the recorded cost, consistency of approach implied that the recorded cost should be excluded and the day case activity and cost de-selected from the 'expected' cost file.

Critical Care Costs

The 'Costing Guidance' for Reference Costing requires that all critical care costs incurred in specially designated Units should not be included in the standard HRG Reference costing. The recorded critical care costs for the hospitals are shown in Table 3.3.

Table 3.3: Critical Care Costs

Name of Hospital	ICU	CIC	HDU	PIC/NIC
Altnagelvin	£2,050,077			
Antrim	£1,696,001	£1,101,703		
Coleraine	£1,212,920			
Craigavon	£2,744,492			
Daisy Hill			£457,221	
Erne	£1,391,205			
Mater	£747,649			
Mid Ulster			£833,640	
Ulster	£2,543,939			
Belfast City	£2,761,136			
Royal Victoria	£5,749,295	£4,044,712	£572,774	
RBHSC				£2,648,650
Royal Maternity				£3,527,868
Total	**£20,896,714**	**£5,146,415**	**£1,863,635**	**£6,176,518**

These critical care costs are not included in the standard HRG Reference Costing. However, the expected costs can be estimated using NHS Critical Care Reference Costs. The modelling carried out (described later) allows critical care costs (both actual and expected) to be included or excluded by the user – provided equivalent actions are taken on both types of cost.

Hospital Specific Costs

Many of the hospitals have specific cost areas that should be excluded (or on occasion added) for a variety of reasons. Table 3.4 outlines these specific modifications to Specialty costs, with notes.

Table 3.4: Special Cost Adjustments to Recorded Costs

Name of Hospital	Cost	Notes
Antrim	**£833,570**	An additional cost for Oncology day cases
Coleraine	£2,856,568 £2,461,876	Dalraida (IP) Mental Illness (IP)
Route	**£276,413**	An additional cost for ENT day cases
Daisy Hill	£408,197	Mental Illness (DC)
Erne	£355,942 £34,490	Geriatric Day Hospital Mental Illness (DC)
Lagan Valley	£277,813	Geriatric Day Hospital
Mater	£803,774 £2,528,106	Mental Illness (DC) Forensic Psychiatry
Tyrone County	£577,119	Paediatric Ambulatory Care
Ards	£1,532,547	Mental Illness (IP)
Whiteabbey	£270,223	Geriatric Day Hospital
Belfast City	£285,515 £544,092 **£5,290,625** £1,925,092 £7,496,544 **£9,825,445**	Geriatric Day Hospital Mental Illness (Day) Oncology (Day) Mental Illness (IP) Unclassified Expenditure (IP) Oncology (IP)
Royal Victoria	£686,202	Geriatric day Hospital

In Table 3.4, additional costs not found in the Specialty Cost returns are shown in bold. The Steering Group has supplied these additional costs.

Inpatient and Day Case Activity associated with Identified Relevant Costs

Information is directly available from the Specialty Cost returns on both activity and cost. However, unfortunately this source of activity data is not, in all cases, easily reconciled to the activity data in the database of individual records for the year 2001. The two sources do not, in all cases, appear to be measuring the same activity in the same way.

Despite this difficulty, it has been essential that (as far as possible) the costed activity be identified accurately in the database records. It is these records that are the basis for the derivation of expected costs and, hence, must also be the basis for making any comparisons with actual costs.

As a result of these considerations, the specialty cost activity and the database activity have been thoroughly and carefully compared and contrasted for all hospitals by specialty, and for both inpatients and day cases.

Agreement between Specialty Cost Activity and the 2001 database

The degree of agreement is gratifyingly high but there were a number of exceptions, shown in Table 3.5. It should be noted that all the required exclusions (additions) have been made from both sources before making the comparisons shown in Table 3.5 – Nephrology, Critical Care etc.

It can be seen that the main differences reflect the presence of extra activity in the 2001 database not identified in the Costing Returns. In only one case – Daisy Hill's Oral Surgery – are there extra episodes the Specialty Costs.

Table 3.5: Significant Differences between the Specialty Cost and 2001 Database

Hospital	Differences between Database and Specialty Cost Returns
Altnagelvin	277 extra Paediatric episodes in Database (IP)
Antrim	347 extra GM episodes in Database (IP) 216 extra Paediatric episodes in Database (IP) 131 extra Oral Surgery episodes in Database (DC)
Coleraine/Route	38 extra Dermatology episodes in Database (DC)
Craigavon (ST)	270 extra Paediatric episodes in Database (IP) 904 extra Oncology episodes in Database (DC)
Daisy Hill	140 extra Paediatric episodes in Database (IP) 301 extra Oral Surgery episodes in Specialty Costs (DC)
Downe	77 extra GS episodes in Database (DC) 20 extra Dental episodes in Database (DC)
Erne	1260 extra Obstetric episodes in Database (IP)
Lagan Valley	Nothing Significant
Mater	51 extra Ophthalmology episodes in Database (IP)
Mid Ulster	1896 extra Paediatric episodes in Database (IP)
Tyrone County	590 extra Paediatric episodes in Database (IP) 168 extra Paediatric episodes in Database (DC)
Ulster Group	Nothing Significant
Whiteabbey	Nothing Significant
City (BPR)	96 extra Neurology episodes in Database (DC)
Royal Group	Nothing Significant

It is, of course, not possible to know with certainty the actual costs of treating the missing episodes – since they appear to be either 'missing' or 'hidden' in the Specialty Costing. However, it has been important not to ignore these costs and, hence, efforts have been needed to obtain 'best' estimates.

The Paediatric and Obstetric divergences have been examined carefully to judge the extent to which they might reflect 'well babies' where costs should not be added but, rather, episodes and costs removed from the database. This particular aspect is discussed in the next section.

In other cases, clearly the specialties (and hospitals) within which the exceptions occur can be identified in the database, which also contains the average expected cost per episode (for both day cases and inpatients). Thus, the number of extra episodes and the average expected cost could be multiplied together to give an estimate of the cost.

These quantities can either be removed from the expected cost or added to the actual cost since these are logically and precisely equivalent actions. It is more consistent with the approach taken in other areas discussed previously to remove the problem activities from the expected cost files. However, all actions actually taken have been those directly specified by the Steering Group in their Reconciliation Exercise.

Well Babies

It is clear from the Costing Guidelines that Well Babies should not be costed, and this activity should not be counted. As far as can be judged, this procedure has been followed in the Specialty Costs. However, it is also clear that these episodes have been recorded in the Database. Unfortunately, the various hospitals have not interpreted these records consistently. In some cases the specialty 'Well Babies' includes babies who are quite clearly not well. In other cases related specialties – Paediatrics, Obstetrics – include babies who appear to be well.

Two alternative approaches have been retained in the final modelling. The first approach has involved taking the results at face value and removing all episodes (and expected costs) classified as 'well babies'. The alternative assumption that has been made in this research is that well babies will have the HRG code N03 – Neonates with one Minor Diagnosis and all these episodes and the associated costs have been excluded from the expected costs.

Careful attention has been needed in order to ensure that well babies have been identified in hospitals that do not use the 'Well Baby' classification.

Final Modifications

In the Royal Group of Hospitals, the Specialty Costs contain the specialty 'Infective Diseases' with 771 episodes at a cost of £758,224. These episodes cannot be found in the Database and, hence, have been removed from the analysis.

The Steering Group have suggested the exclusion of episodes in Anaesthesia because of possible double counting, and provided data on these problem episodes, as shown in Table 3.6.

Table 3.6: RE Document – Excluded Anaesthesia Episodes

Hospital	IP	DC
Craigavon	29	
RBHSC	366	
RVH	670	
Ulster	323	
Tyrone County	4	115
Erne	7	16

Final Result

Following all the stages outlined above a final Table of Actual Costs and Activity has been produced for each hospital group – as shown in Table 3.7.

Table 3.7: Activity and Cost in NI Hospitals

Activity and Cost in NI Hospitals				
Altnagelvin	11545	£4,330,499	25745	£36,895,177
Antrim	7491	£2,846,640	23453	£27,976,101
Coleraine/Route	4015	£2,255,383	10416	£20,365,220
Craigavon	9199	£2,194,128	26490	£35,280,518
Daisy Hill	2795	£1,084,616	13034	£16,299,094
Downe	1613	£764,337	5287	£8,164,802
Erne	1985	£525,650	10697	£14,944,146
Lagan Valley	3551	£1,401,118	7045	£12,285,927
Mater	4186	£1,479,457	11275	£12,919,945
Mid Ulster	2073	£884,204	8405	£11,116,897
Tyrone County	2700	£1,103,558	7913	£9,855,046
Ulster Group	15498	£5,060,590	32745	£44,444,879
Whiteabbey	3237	£1,522,444	4915	£10,142,194
City	19469	£8,802,775	29937	£59,538,286
Royal Group	21010	£8,657,575	48982	£109,130,068
	110367	**£42,912,974**	**266339**	**£429,358,300**

Note that the costs in Table 3.7 include capital charges and critical care costs but private patients have been excluded from the activity.

Critical Care Costs

The results shown in Table 3.7 include critical care costs. However the modeling approach that has been taken allows these costs to be excluded if the user wishes. This has been done by using the NHS Critical Care Reference Costs to derive an 'expected' critical care cost for each hospital. The actual bed days recorded in the Specialty Cost Returns for each type of critical care have been multiplied by the relevant NHS Reference Costs.

Regression Modelling

The General Approach

The essence of the approach taken has been to derive an expected cost for each hospital based on a mix of NI and NHS HRG weights for day cases, surgical electives, medical electives, surgical non-electives, medical non-electives, excess bed days and critical care. These expected costs could then be compared with the actual revenue costs and differences related to activity levels (using the combined volumes of day cases and inpatients).

This is a similar approach as that taken in the work done for the Arbuthnott Report in Scotland.

In principle, the approach taken allows each hospital to be considered separately. However, allowing certain hospitals to be 'grouped' together has produced the main results. The groups in question are the Royal Group – Royal Victoria, RBHSC and Royal Maternity – and the Ulster Group – Ulster, Ards and Bangor – Coleraine and Route. In addition Belfast City has required consideration of some activities at Belvoir Park and Craigavon has required consideration of some activities at South Tyrone.

The justification for the groupings is that the individual component hospitals are effectively inseparable.

Expected Excess Bed Days

As has been described in the section above on 'Analysing Expected Costs', the results incorporate the estimation for each hospital of expected excess day costs (and quantities).

It is important to recognise that around 10% of total inpatient cost in NHS hospitals is associated with excess bed days – an important area of cost that must be incorporated in the analysis.

It is clear both from the data available from NHS Reference Cost sources and from previous research that excess bed days are less costly than non-trimmed bed days.

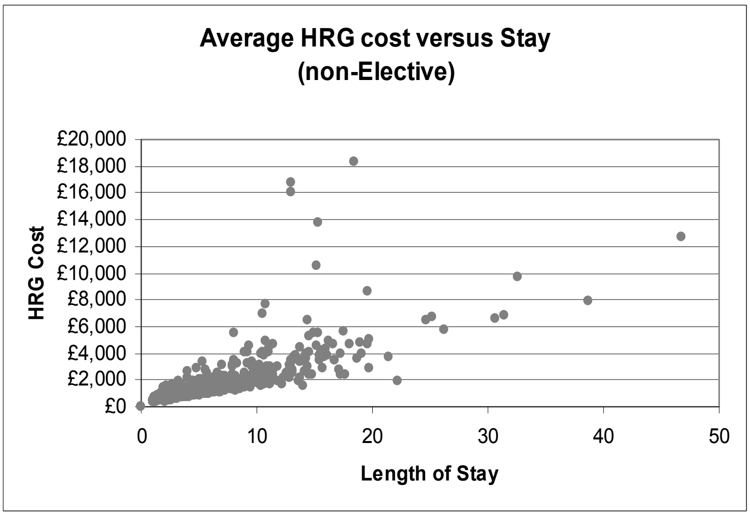
Coverdale, Gibbs and Nurse[13] fitted a model to hospital costs of the form:

Cost = hotel cost + treatment cost

This showed that, for the average acute patient, treatment costs are high in the early stages of a patient stay and fall quite rapidly towards the hotel cost as stay progresses. Thus days after the expected stay has been reached will have a lower average cost than the days up to this point.

Support for this analysis is provided by plotting the expected cost against expected stay using the NHS HRG reference cost data. Figure 3.3 shows this pattern for non-elective inpatients and the lower boundary edge of the relationship is almost linear. (A similar picture is found with elective inpatients).

Figure 3.3: Average HRG cost versus Expected Length of Stay



It can be seen that the hotel cost is rising directly proportional to stay and that the treatment costs are accumulating rapidly at relatively short stays.

The most convincing illustration of these relative bed day costs above and below the trim levels of stay is the NHS Reference Cost file appertaining to Excess Bed Day costs. This file provides the following data for each HRG and for Electives and Non-Elective Inpatients.

- HRG Code
- Average Reference Cost
- Average Non-Trimmed Length of Stay (Days)
- Total Number of Bed Days across all Episodes

- Total Number of non-Trimmed Bed Days across all Episodes
- Total Number of Excess Days across all Episodes
- Total Resources in Excess Bed Days across all Episodes
- Total Resources in non-Trimmed Bed Days across all Episodes
- Total Number of Cases (by HRG)

The totals (NHS) across all HRG Codes for Electives and Non-Electives for key measures are shown in Table 3.8 below.

Table 3.8: Relative Costliness of Trimmed and Non-Trimmed Days

Measure	**Electives**		**Non-Electives**	
	Cost (£mill)	Days	Cost (£mill)	Days
Total Non-Trimmed Costs and Days	£213.4	1146463	£1092.2	6605065
Total Trimmed Costs and Days	£2870.3	6608998	£6504.9	25598582
Cost Ratios =		**43%**		**65%**

This table shows that overall elective inpatient excess days cost 43% of non-trimmed day cost. The ratio for non-elective inpatients is higher at 65%.

The ratios differ between HRGs but the average values can be obtained for all specialties (by using the episode-weighted distribution of HRGs by Specialty) for both methods of admission. This is the approach taken in the first method described in (3) in the section describing the 'Selection Model' (above).

<u>Actual Excess Bed Days</u>

The expected excess days and costs have been incorporated into the total expected costs of each hospital. However, the individual episode record database also allows the <u>actual</u> excess bed days to be derived. Clearly the costs associated with these days are already included in the Costing Returns.

The question arises concerning whether some of this cost should be deducted from the actual costs – on the grounds that it is an 'avoidable' inefficiency that might contaminate the identification of scale effects. Although there are alternative views on this matter it has been decided that any 'extra' excess days above (or below) the expected values should be costed and this cost excluded from the actual costs. With the exception of Belfast City, the actual number of excess days in NI hospitals is greater than the expected values – ranging from 0.02 days per inpatient episode at Tyrone County to 1.32 days per episode at Whiteabbey. At Belfast City there is a 'saving' of 0.83 days per episode.

Two methods of costing are available to the User in the modelling – costs per bed day in line with the research findings or, alternatively, at the overall average cost per bed day (for the hospital in question).

Relationships between Activity, Relevant Actual Costs, Casemix Adjusted Costs and Scale

The Relationship between Total Cost and Activity

All the results presented in this section are based on the following input scenario:

- Expected and Actual Critical Care Costs are Included
- The Adjustment for Actual Excess Bed Days is Included
- The NHS-derived relative cost per excess day (to standard days) is Selected
- Costs exclude capital charges

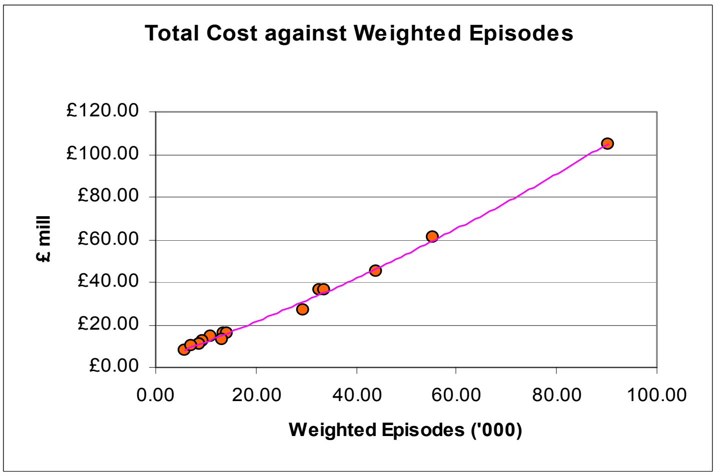
In this research other input scenarios have also been evaluated.

It is important to assess the manner in which the total cost of running hospitals is related to the levels of activity. Figure 3.4 shows the total cost (adjusted for capital charges) charted against casemix-weighted activity.

In order to derive this chart the relative expected cost per case has been used as a multiplier of the recorded activity – inpatient plus day case episodes. Thus, for example, if the activity in hospital A is 1000 episodes and in hospital B it is 2000 episodes, and the cost weights are 1.2 and 0.9 respectively then hospital A has 1,200 and hospital B has 1,800 weighted episodes.

Cost weights are derived by dividing the hospital’s expected cost per episode (obtained in the manner described earlier) by the overall cost per episode for all hospitals combined. Thus the overall weight across the set of hospitals studied is equal to unity.

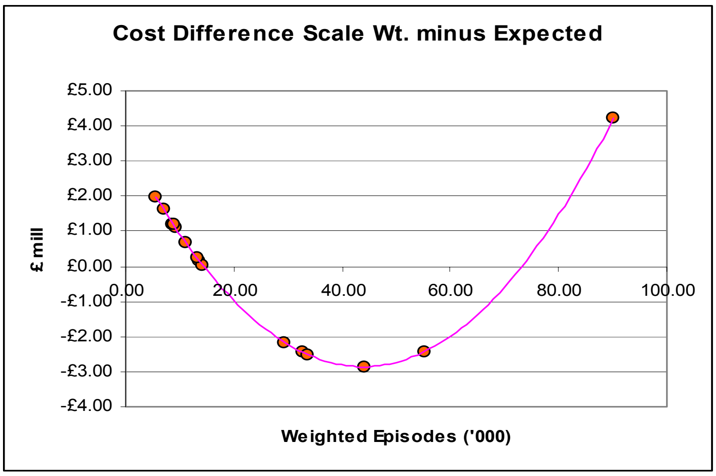
Figure 3.4: Total Cost against Casemix-Weighted Activity



The relationship (a polynomial of order = 2), indicated by the fitted line has a very high R^2 value (above 99%). The residual errors have been analysed and the errors appear to be totally <u>unrelated</u> to scale (levels of activity). The costs predicted by the modelled line in Figure 3.4, which will, of course, <u>include</u> any scale effects, have been compared with costs that are in direct proportion to weighted episodes – i.e., the expected costs. The total <u>cost differences</u> are shown in Figure 3.5.

There is a clear and distinct pattern in this result with the smaller hospitals showing a greater total cost when this cost is derived from the regression line in Figure 3.4 (referred to here as scale weighted) than if the cost is based on proportionality with weighted episodes. The mid-range hospitals show lower total costs than would be expected and the (single) very large hospital shows a higher cost.

Figure 3.5: Cost Differences between Expected Cost and Scale-Weighted Cost



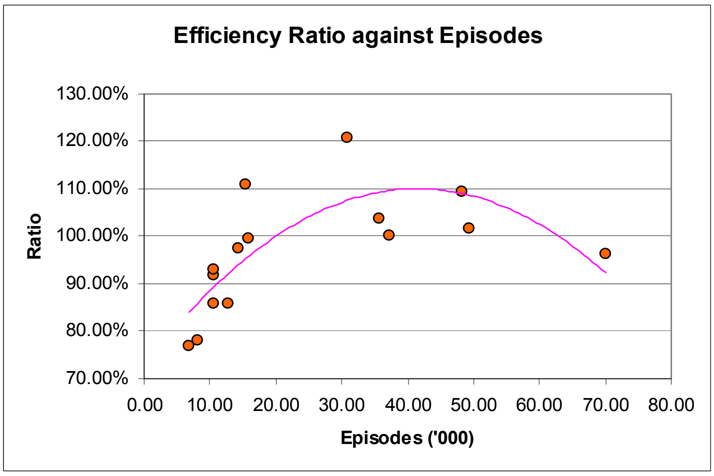
Clearly Figure 3.5 supports the hypothesis that a scale effect exists but also suggests that this effect is non-progressive as size increases and that an optimal size exists for hospitals, below which scale costs are experienced and above which diseconomies of scale return. There is support in the literature (see, for example, Coverdale et al[13]), for this conclusion. However, there remains uncertainty in this interpretation since any function is very sensitive to the single observation representing the largest hospital – the Royal Group.

Cost Efficiency Ratios

If cost efficiency is considered to be associated with treating patients at a cost that is below that expected from the casemix-weighted costs and inefficiency associated with actual costs that are greater than expected then the ratio of the two costs should reveal this effect.

The expected costs have been reconciled to equal the actual costs in total. However it should be noted that, without reconciliation, the total expected cost is around 3% greater than the actual cost. Charting the Efficiency ratio against the episodes yields Figure 3.6.

Figure 3.6: Efficiency Ratio against Episodes



Clearly the small hospitals again appear 'less efficient' on this particular indicator – with only one of the nine 'small' hospitals clearly above 100%. The picture for the larger hospitals is not quite as clear, although the majority are clearly above 100%. The best fitting function for the data in Figure 3.6 is a polynomial (of order =2) and this has an R^2 value of around 61% and this is statistically significant at better than the 1% level.

Quantifying the Scale Effect

Evidence has been presented above for the existence of scale cost effect in Northern Ireland hospitals – illustrated in relation to total costs (in

Figure 5) and in relation to cost ratios between expected and actual costs (in Figure 6). This evidence is convincing in relation to the existence of a systematic effect but it is less certain in relation to the true 'shape' of this relationship.

Although previous research outlined earlier tends to support the notion of an optimal hospital size, it provides very little guidance on the possible reasons for the return of diseconomies for hospitals that are larger than this optimum. This problem is complicated in the case of Northern Ireland hospitals where the one very large hospital is, in fact, a group of hospitals – the Royal Group. Although this group is integrated in the management sense, there is some concern over the extent to which the constituent hospitals might remain partially independent. Clearly this is an important concern since any progressive model of scale effects, where increasing size provides increasing opportunities to exploit scale economies, will be confused or hidden by any purely administrative grouping of hospitals together.

Despite these difficulties of interpretation, particularly for relatively larger hospitals, it is necessary to reach a conclusion on the most likely form of the scale effects model in order to estimate EoS costs as a function of activity – the main purpose of this study. The judgement has been reached that, in the context of the main objectives of this study, the statistical evidence should be accepted at face value. A polynomial function (giving an optimal hospital size) does fit the data better than a progressive function and, hence, should be accepted *pro tem*.

The reasonable assumption has been made – supported by the relationship shown in Figure 4 – that the principal basis for funding should relate directly to the total expected costs of the hospitals. Figure 5 shows that the pattern of actual costs does support this assumption but shows a significant variation from this ideal that is directly related to the scale of activity.

Thus a sensible refinement would be an approach that modifies this expected-cost based funding as a result of the identified scale effects – using either the total cost approach or the efficiency ratio approach. The aim has been to quantity this required modification.

The proposed method for doing this is as follows:

If, for each competing hospital...

$$\left(T_s.F\right) = \left((E_s.(F - B)) + (S_s.B)\right)$$

Where T_s = the required share of total funding
F = the Total funding budget
E_s = the share based on expected costs

B = the Economy of Scale budget
S_s = the share of the scale budget

Then...

$$S_s = (((T_s - E_s).F) / B) + E_s$$

Thus for any input values of F and B the hospital's share of B can be calculated, provided that the required final funding share is known. Furthermore the input value of B will not affect the final required funding. An appropriate level to set for the top-sliced value of B would be such that the most scale-efficient hospital would have a share of approximately zero.

Obtaining Estimates of T_s and E_s

Obtaining E_s is straightforward. The Selection Models, set up to reflect as exactly as possible the activities costed in the modified Specialty Costs, give the total expected costs of each hospital. These costs (shown in Table 9) divided by the total across all hospitals provide the shares required.

There are two possible approaches for obtaining an estimate of the required shares – using the total costs approach (Figure 3.4) or the efficiency ratios approach (Figure 3.6).

In the total costs approach the regression equation for the curve shown in Figure 4 can be used directly. In order to use the efficiency ratio approach, the ratios obtained from the function fitted to the data in Figure 6, can be used to divide into the expected costs to produce a scale-adjusted expected cost. In other words the scale-adjusted cost for each hospital is equal to the expected cost divided by the predicted efficiency ratio.

The two methods give very similar results for T_s. Although the regression approach (using total cost) is arguably more secure theoretically, the ratio approach has the advantage, for our purposes, of being a direct relationship between recorded activity and scale cost effects.

Overall Results

Results are available for a number of input scenarios. The functions (and the R^2 values) for predicting relative EoS cost per episode are shown in Table 9. The scenarios considered are:

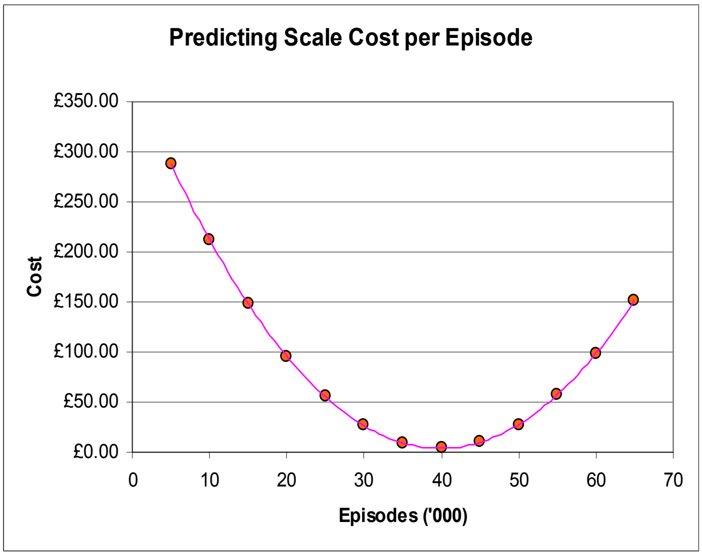
- Scenario A: Critical Care Included, Excess Day Costs Adjusted, At Full Cost
- Scenario B: As A, but at NHS Costs per Excess Day
- Scenario C: As A, but no adjustment for Excess Days
- Scenario D: As C, but Critical Care Excluded

Table 3.9: Best Fitting Functions for Alternative Scenarios

Scenario	Scale Cost per Episode (£)	R^2 (of the Ratio Relationship)
A	$0.2309\ x^2 - 18.4049x$	54.8 %
B	$0.2335\ x^2 - 18.6201x$	60.5 %
C	$0.237\ x^2 - 18.9064\ x$	63.5 %
D	$0.1947\ x^2 - 15.9428\ x$	68.8 %

The constants in the above functions have not been included. Episode numbers (x values) are measured in thousands. Clearly there are other scenarios that can be evaluated but the selected ones provide a good picture of the range of possible results. For illustrative purposes, Figure 9 shows the result for scenario B. The results in Table 3.9 in fact reflect a family of curves all of which reach a minimum value in the region of 40,000 episodes. This illustration has charted results between 5,000 and 65,000 episodes.

Figure 3.8: An Illustration of an EoS Function



40,000 episodes per annum equates to circa 400-500 available beds considering NI typical values for lengths of stay in the acute sector.

Conclusions

Models have been produced and procedures developed that can be applied directly to the results of the activity modelling of alternative hospital configurations and various applications of these models are described in the following two chapters.

Most of the illustrations presented here have been based on a particular scenario in terms of the choices available within the so-called Selection Model for each hospital. Clearly changing this scenario will change the detailed results. However, none of the available scenarios yield results that substantively change the main conclusions reached concerning the existence of scale effects, judgements concerning the form of this relationship or the methodology proposed for the quantification of these effects.

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