
CHAPTER 4: Applications of Hospital Scale Modelling – Current Hospitals

The analyses and modelling described in the previous chapter can be applied directly to the evaluation of scale cost effects in the provision of the current acute hospital services in Northern Ireland. In fact, in terms of costing the set of main hospitals, these scale cost estimates are quantifiable directly from the work presented earlier. However although values for the scale budget (B) and the shares (S_s) can be derived in this way, this does not directly answer the question of where these costs fall in relation to the Health and Social Services Boards (or other administrative units) in the Province. This problem arises because of significant cross-boundary flows of patient treatments.

The main aims in this chapter are (a) to quantify the scale costs for hospitals and (b) attribute these costs back to the four Boards – Eastern, Northern, Southern and Western.

Scale Costs for Current Hospitals

Total Costs

Following on from the work presented in the previous chapter, the total (known) actual costs of each hospital can be represented by the following expression:

$$\text{Total Cost} = \text{Reference Cost-based Expected Cost} \\ + \text{Scale Cost} + \text{or} - \text{Residual Cost}$$

Where the Expected Cost arises from the hospital's 'expected' share of the total budget (F) minus the scale budget (B) and the Scale Cost from the scale-cost functions developed.

Applying the costing for Scenario B, as described in the previous chapter, to the hospitals gives the costs shown in Table 4.1. The hospitals are not named to protect confidentiality.

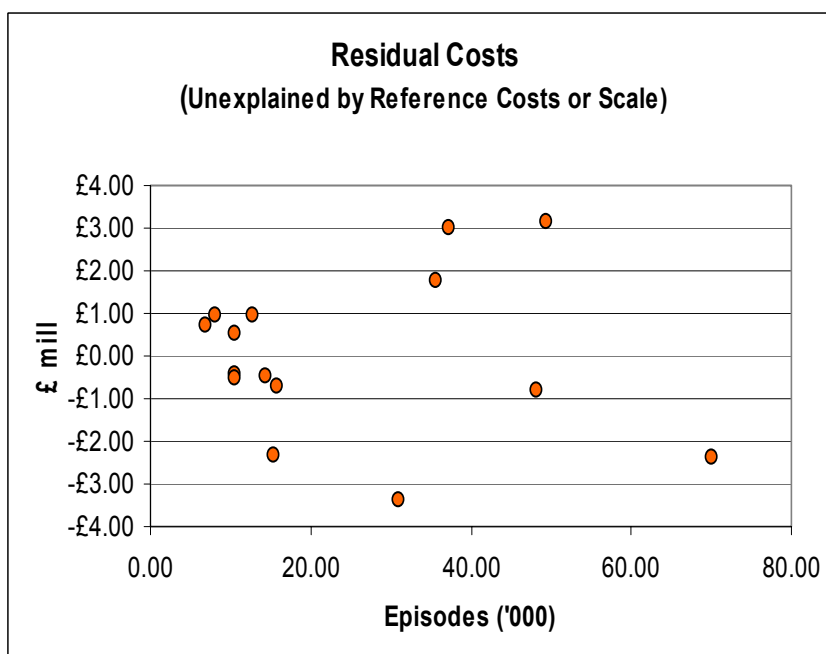
Table 1: Components of Total Hospital Cost

Total Costs	Expected	Scale	Residual
Hospital 1	£5.80	£1.74	£0.71
Hospital 2	£7.18	£1.91	£0.96
Hospital 3	£8.97	£2.10	-£0.41
Hospital 4	£9.01	£2.11	-£0.54
Hospital 5	£9.50	£2.11	£0.50
Hospital 6	£11.39	£2.17	£0.95
Hospital 7	£13.47	£2.13	-£2.33
Hospital 8	£14.04	£2.16	-£0.48
Hospital 9	£14.63	£2.12	-£0.70
Hospital 10	£30.10	£0.54	-£3.39
Hospital 11	£33.38	£0.01	£3.01
Hospital 12	£34.15	£0.10	£1.76
Hospital 13	£45.12	£0.73	-£0.83
Hospital 14	£56.61	£0.99	£3.16
Hospital 15	£92.26	£14.75	-£2.38
Totals	£385.60	£35.69	£0

The scale budget of £35.69 million is simply a result of the most scale-efficient hospital being 'engineered' to be reasonably close to zero (by setting the constant term in the scale cost function). Reducing this value would result in negative costs in the scale column, which is undesirable, and increasing it will not change the differential scale costs.

The residual costs are costs that are unexplained by either Reference Costs or by scale effects, and by definition must total zero. It can be seen in Figure 4.1 that these costs appear (as is required for the scale costing to be regarded as logically sound) to be unrelated to scale. The hospitals with residual costs that are below zero show cost savings and those above zero face extra costs – for reasons that are not known.

Figure 4.1: Residual Costs against Activity



Distributing the Total Funding

The only costs that have distributional relevance in this study are those costs shown in the scale column of Table 1. Although an argument can be mounted for using the combined costs of the 'expected cost' column and the 'scale cost' column as an efficient basis for distributing the total funding, this would be a (controversial) widening of the scope of this research. The focus here is that of distributing the notional top-sliced scale budget (B) so that hospitals are compensated for differential scale-related costs.

Because funding is not shared directly between hospitals but is shared between Boards, it is necessary to determine each Board's share of the scale budget. In terms of the hospitals operating within each Board this is straightforward and is shown in Table 4.2.

Table 4.2: Scale Budgets for Hospitals within Boards

Board	Scale Budget
Eastern	£22,460,446
Northern	£6,709,393
Southern	£2,221,302
Western	£4,296,868
Total	£35,688,009

Although the result shown in Table 4.2 might have some relevance, the costs are not attributed in any way to the Board of residence of the patients treated in the hospitals. The large Eastern hospitals, in particular, attract large numbers of patients from all over Northern Ireland.

In the next section a method for attributing the scale costs back to Board-of-Residence is described.

Scale Costs by Board of Residence

Method of Approach

The scale cost budget can be regarded as a quantum of cost that (notionally) needs to be recovered from all patients treated. At its simplest the scale cost for any hospital can be apportioned between the Districts from which the demand arises in proportion to the relative demand levels. Equivalently, the scale cost for each hospital can be divided by the episodes to give an equal shadow price for each episode. If the Board-of-Residence of each episode is known these 'prices' can be accumulated across all hospitals used by the residents of each Board. Although this assumption of equal 'price' per episode (by hospital) can be questioned, any differential pricing by episode type and specialty mix would require data not available to the researcher and, even if this were to be obtained, would lead to serious complexities in the modelling.

Data on Cross-Boundary Flows

The Project Analysis Support Unit supplied information on the flows of total activity between Local Government Wards and each hospital in Northern Ireland for 2000/01. Because these episode data are not differentiated by specialty it is not possible to precisely reconcile hospital activity with the actual activities used in the analysis of scale costs. However the general pattern of agreement is reasonably good.

The assumption has been made that the proportional demand from Wards on each hospital studied in this project is reasonably reflected in the analysis of the supplied flow records. Thus if the actual agreed activity level for hospital A is 1000 episodes and the flow analysis shows 60% from Ward X and 40% from Ward Y, then 600 episodes arising at hospital A can be attributed to Ward X and 400 episodes to Wards Y. Clearly results for Wards can easily combined to give Board-level flows. These are shown in Table 4.3 for the 15 main hospitals/groups.

Table 4.3: Proportional Flows from Boards to Hospitals

Proportional Flows from Boards				
Hospital	Eastern	Northern	Southern	Western
Hospital 1	94.51%	0.15%	5.26%	0.08%
Hospital 2	5.04%	94.88%	0.04%	0.05%
Hospital 3	0.17%	98.26%	0.70%	0.87%
Hospital 4	0.17%	0.37%	8.02%	91.44%
Hospital 5	83.63%	2.03%	14.20%	0.13%
Hospital 6	0.46%	0.35%	4.19%	95.00%
Hospital 7	73.90%	23.84%	1.50%	0.76%
Hospital 8	1.00%	96.02%	0.36%	2.62%
Hospital 9	0.85%	0.11%	98.97%	0.07%
Hospital 10	0.98%	98.71%	0.19%	0.13%
Hospital 11	0.22%	5.25%	0.49%	94.04%
Hospital 12	1.70%	2.84%	94.76%	0.70%
Hospital 13	90.56%	4.28%	3.81%	1.35%
Hospital 14	75.45%	14.74%	7.65%	2.16%
Hospital 15	63.41%	20.16%	12.07%	4.35%

The detailed modelling of scale cost 'flows' has been carried at District level because interest has been expressed in results at below-Board levels. However a ward level analysis has not been attempted.

Results

Using the 'shadow' pricing method outlined above gives the estimates of Board level EoS costs shown in Table 4.4.

Table 4.4: Scale Budgets for Boards

Board	Scale Budget
Eastern	£15,913,273
Northern	£10,209,306
Southern	£4,786,285
Western	£4,779,145
Total	£35,688,009

Comparing the results in Tables 4.2 and 4.4 shows that the incorporation of cross boundary flow effects makes a significant difference to the Board shares of the total scale fund.

Implications for Funding

If the Scale budget were to be shared between the Boards in accordance with the so-called capitation weights, the shares for the four Boards would be 42.16%, 23.66%, 17.67%, and 16.51% respectively – Eastern, Northern, Southern and Western Boards. In Table 4.5 these shares are quantified and compared with the EoS cost budgets shown in Table 4.4.

Table 5: Comparing EoS Budgets with Capitation Shares

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

This would 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.

However, such a conclusion raises the key question that lies at the heart of this research – to what extent are the scale-related costs identified in the study of the operations of the current hospital service a valid indication of unavoidable scale costs? Thus, for example, the relatively high scale costs faced by the Eastern Board (and because of large cross-boundary flows into the Eastern area by Northern Board residents – by the Northern Board) result mainly from the high diseconomies of scale estimated for a large Eastern hospital group.

It is an obvious statement (based on the modelling presented in the previous chapter) to say that scale costs can be minimised if hospitals approach the optimal size – small hospitals becoming larger and large hospitals becoming smaller. Thus the critical question becomes that of whether there are reasons why hospitals must unavoidably fail to achieve this ideal state.

Reasons can quite easily be seen in relation to some of the smaller hospitals – that the demands ‘available’ within the catchment areas of these hospitals might limit their ability to increase capacity. However, the reasoning is not so clear in relation to hospitals that are currently larger than the ‘optimum’. The types of high-level treatments associated with a major ‘Regional’ centre might (a) lead to extra costs not adequately reflected in the HRG-based expected costing and (b) might lead to an unavoidably large scale of operations.

This difficulty relates to problems of interpretation of scale cost relationships discussed in the previous chapter, where it was pointed out that the parameters of the fitted polynomial functions are very dependent on the actual costs and activity of a single very large hospital.

Conclusions

In this chapter the scale models developed in the previous chapter have been applied to the operations of the current hospital service. In the presentation only one scenario has been illustrated. This is Scenario B,

costs of critical care are included, excess day cost adjustments have been allowed and the basis of the costing of excess days has been the NHS-derived values. Other scenarios can be shown to give very similar overall conclusions.

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 and this approach is described in the following two chapters.

CHAPTER 5: Hospital Services: Access and Activity Modelling

This chapter describes a methodology (and its findings) that has been used to supply activity level outputs as a basis for analyses aimed at assessing any differential levels of unavoidable cost of hospital service provision that arise from different 'scales of operation' found to be necessary within the four Health Boards in Northern Ireland.

This approach has, for reasons outlined below, taken a theoretical stance in the sense of being based on access model-derived 'optimum' locations for service and estimates of the types and levels of activity that would take place at and from these 'notional' locations.

The actual current pattern of hospital service provision within these Boards has not been incorporated in this modelling. This analysis is intended to complement rather than replace other analyses of the effects of current service provision, as described in the previous chapter.

Rationale

It is self-evident that any existing service provision will have been subject to a very wide range of historical, political, cultural and organisational influences and that population distribution effects on the scale of individual operational units might well be very difficult to isolate from the combined effects of these influences. There is no certainty, for example, that the current existence of a small hospital (or a very large one) with relatively high unit costs is in any sense the unavoidable result of the population distribution characteristics of the area served and there might well be many other reasons for the situation that has arisen.

As a way of unearthing and isolating possible population distribution effects from other effects a 'clean-sheet' approach has been taken in the work reported in this chapter. This approach, in essence, seeks to answer questions concerning the locations and sizes of acute hospitals that should be provided if the relative needs for service are to be equitably met in the different areas of Northern Ireland in an 'optimal' manner.

The concept of optimisation used here reflects an attempt to minimise the number of hospital units required subject to access requirements and, where relevant, constraints on both minimum and maximum feasible sizes for these units. Although clearly there is little chance that such an

optimised service could be realised in practice, the approach has been designed to reveal any inherent (and unavoidable) scale-efficiency effects that result directly from the unique spatial properties – population distribution and settlement patterns – of the areas being served in Northern Ireland.

Conceptualising the Service

A Three Level Hierarchy

Following the strategic thinking presented in reports such as ‘Putting it Right’ this service has been conceived as operating within a three-level hierarchy. At the top of this hierarchy (Level 3) sit hospitals that are capable of providing the full range of acute services including regional services that require highly skilled practitioners and the latest technologies. At the next level (Level 2) are hospitals operating at an area level that are capable of providing all but the most specialised and technologically advanced treatments and care. The final level (Level 1) incorporates the provision of strictly local or community-based services.

The conceptual model adopted assumes that all hospitals can provide Level 1 type services to their local communities, that Level 2 hospitals can also provide Level 2 services and that Level 3 hospitals can provide the full range of services.

Access Objectives

The Steering Committee for this study agreed that access performance requirements for the three types or levels of treatment/care should be different as shown in Table 5.1.

Table 5.1: Access Performance Requirements

Level of Treatment/Care	Access Requirement
Level 1	95% within 30 minutes driving time
Level 2	95% within 45 minutes driving time
Level 3	95% within 60 minutes driving time

It was also agreed that these requirements should apply, as far as possible, to all communities in the Province and that Local Government Districts would be an appropriate level of evaluation. Thus the access objectives imply that the input percentage should be read as the proportion of each LGD that should be within the access driving times agreed.

The requirement to meet access requirements at LGD level is a much more stringent access requirements adopted in other studies of health service accessibility in N Ireland in recent years, which have tended to focus on the NI population as a whole when setting such criteria. The

rationale is that it is possible and desirable to be more stringent in a theoretical scenario in order to properly isolate the effect of scarcity on cost.

Volume/Sustainability Objectives

It was agreed by the Steering Group that sustainability could be regarded as dependent upon the minimum catchment populations that hospitals at different levels can 'attract'. The population indicator used has been the 'acute service' weighted population of the enumeration districts attracted. It has been assumed that any enumeration district will be linked to the nearest (in driving time) appropriate hospital. No minimum value has been set for Level 1 hospitals, and an acute-weighted population of 55,000 persons was set at Level 2 and an acute-weighted population set of 100,000 for Level 3.

The Steering Group did not propose any formal constraints on the maximum catchment populations for hospitals. However, as has been shown in a previous chapter some current hospitals are larger than the optimum size in relation to the scale-cost functions that have been derived. In relation to the theoretical approach taken here it has been decided that no hospital should operate at above the optimal size. The optimal size is not invariant of the scale-costing scenario used but is unlikely to be above 45,000 episodes – equivalent to a catchment population of around 200,000.

The Optimisation Objective

The hypothesis relating to economies of scale implies that *ceteris paribus* a larger unit of activity (up to the optimum size) will incur lower unit costs than a smaller unit. Exploiting such possible economic efficiencies is likely under most circumstances to be formally equivalent to minimising the total number of operating units subject to the agreed access and sustainability criteria.

Methodology & 'the Rules'

In essence, the access model used estimates (using GIS data for Northern Ireland) the expected driving times from all enumeration districts to all locations within an input set of 'notional' hospital locations. From these estimates all EDs can be 'assigned' to the nearest appropriate hospital and the catchment populations associated with each input location determined. ED populations are based on the 1991 Census as the results of the 2001 Census were not available at the time the work was undertaken. However, it is thought that the optimisation routine is fairly robust to relative population changes in the intervening period.

Any hospital scenario can be input from the total available set of population centres (described later). The aim has been to derive the optimum set of locations and the set of rules designed to achieve this aim is detailed below.

The Rules

Building from the description above the following algorithm was defined:

- ◆ No hospital can operate at Level 2 if it cannot operate successfully at Level 1. Similarly, no hospital can operate at Level 3 if it cannot operate successfully at Levels 1 and 2. Thus, Level 1 hospitals must be located first, followed by level 2, followed by Level 3.
- ◆ The procedure starts with all possible locations present and removes locations in reverse order of potential workload (demand attracted), allowing the location to be removed if no specified requirements are broken.
- ◆ The requirement for a Level 1 solution is that access performance in all LGDs (as far as it is feasible) must be that at least 95% of demands can be met within 30 minutes. There is no formal minimum workload at this level.
- ◆ If any district cannot be brought up to the required access performance with any locational option, the best level it can achieve must be maintained.
- ◆ When Level 1 is complete, Level 2 requirements are introduced. These are that in all LGDs access performance requires at least 95% of demands to be reached in 45 minutes and that no workload (demand attracted) is less than that associated with a catchment population of 55,000 acute-weighted population.
- ◆ As in step 2, the Level 1 hospitals are assessed in reverse order of potential workload attracted and a hospital removed (from consideration as a level 2 status location) if and only if no requirement is breached.
- ◆ When Level 2 is complete, Level 3 requirements are introduced. These are that in all LGDs access performance requires at least 95% of demands to be reached in 60 minutes and that no workload (demand attracted) is less than that associated with a catchment population of 100,000 acute-weighted population.
- ◆ As in step 2, the Level 2 hospitals are assessed in reverse order of potential workload attracted and a hospital removed (from consideration as a level 3 status location) if and only if no requirement is breached.

Hospital Locations

The procedure (following the above rules) started with all possible locations for hospitals being included in the access model.

The set of possible locations used for hospital analysis incorporates the so-called 'population centres' in Northern Ireland identified in a previous study by the authors in 1997. There are 37 such centres and they represent the identifiable ED 'clusters' in the Province. Clearly in theory it is possible to consider other locations for acute hospitals. However it is unlikely that locations outside of the set chosen would meet the infrastructure requirements (specified, for example, in the Hayes' report) for a sustainable acute hospital.

Supplementary Allocations where Maximum Volumes are involved

Operating the rules described above can lead to the identification of a set of feasible hospitals such that one or more might have a catchment population above the optimum value. For example, Belfast as such has only one 'population centre' but it is, of course, a highly populated centre. Locating a single hospital in Belfast would inevitably result in a hospital that is too large. It was agreed that, in such circumstances, further (nearby) locations could be introduced to divide up the workload. Similar situations can, in principle, also arise elsewhere in Northern Ireland. The supplementary rules are as follows:

- ◆ If in any run a hospital location attracts more than 200,000 of weighted population this population will be further sub-divided in order to minimise the scale costs.
- ◆ The minimisation routine uses the scale cost functions developed in this research. That is, if we have the requirement to split the total hospital demand in a given location because maximum volume constraints are breached, each split can be scale-costed using the preferred function from the regression analysis. The best split is that which minimizes the total scale cost.
- ◆ If the minimisation yields any hospital that breaches any minimum catchment volume requirements then this hospital is brought up to the minimum and volume decreased for the largest hospital in the set.

Results: optimal configurations

Four main runs of the model have been carried out – using either so-called SMOSS default journey times or alternatively congestion-weighted journey times and using either acute service-weighted enumeration district populations or alternatively crude populations.

In practice the two alternative population bases did not result in any operationally significant differences and only the acute-weighted results are presented here. However the alternative journey time assumptions do produce significant differences in terms of locations chosen and the allocation of catchment populations.

Both sets of results meet all the catchment volume requirements specified in the rules. However in relation to access performance both scenarios at

level 1 fail to reach the 95% access within 30 minutes in some Districts – with performances in the 85% to 95% range in the districts of Fermanagh, Moyle and Ards. At levels 2 and 3 all requirements are met.

The hospital locations are shown in Table 5.2

Table 5.2: Population Centre Locations selected by the Access Model

SMOSS Journey Times	Congestion-Weighted Journey Times
Level 3	Level 3
Enniskillen	Enniskillen
Londonderry	Londonderry
Ballymena	Ballymena
Newry	Portadown
Belfast	Belfast
Level 2	Newtownards
Omagh	Level 2
Coleraine	Omagh
Ballynahinch	Coleraine
Newtownards	Newry
Level 1	Downpatrick
Castledearg	Level 1
Magherafelt	Stabane
Ballycastle	Magherafelt
Dungannon	Ballycastle
Armagh	Armagh
Newcastle	Kilkeel
Newtownabbey	Lisburn
	Carrickfergus
	Donaghadee

Estimating Demand Levels

Overall Demand

In the study of the current acute hospitals, described in a previous chapter, the overall demand – day cases and inpatients – is 376,706 episodes per annum. This represents a demand rate per head of population of around 22.4 %. It is these episodes that need to be treated in the set of 'new' hospitals. The question is how these episodes should be apportioned between the hospitals.

Clearly, in relation to the theoretical approach being taken, any episodes categorised as Level 1 type should be allocated to the nearest hospital in the total set of hospitals, level 2 type episodes to the nearest Level 2 or Level 3 hospital and Level 3 episodes to the nearest Level 3 hospital.

Running the access model has provided the catchment areas and populations at these three levels. However, in order to convert this information into episodes, the overall balance of the three types of treatment is required.

The Balance of Activity between Levels

The year 1999 pattern of hospitals and activity has been used to estimate activity appropriate to the three theoretical hospital levels. This earlier year has been used because some smaller hospitals have been closed or downgraded in later years – reducing the available information on local hospitals.

A number of the (then) current hospitals could be regarded as providing mainly local-level services.

Entering all the hospital locations into the Access Model and allocating populations to the nearest hospital allows the total catchment population associated with the level 1 (only) hospitals to be estimated approximately. The estimated annual demand rate from this evaluation is around 0.042 episodes per head of population.

The other hospitals, other than the local hospitals, were assigned to Level 2 or Level 3. Six level 3 hospitals were designated – Antrim, Craigavon, Altnagelvin, the Royal Group, the Ulster Group and Belfast City. All others have been regarded as Level 2.

Using the Access Model in the manner described for local hospitals gives annual demand rate estimates for Level 2 of around 0.082 and Level 3 of around 0.099 per head of population.

The resulting estimate of the overall balance between episode types is:

Level 1	18.8%
Level 2	36.9%
Level 3	44.3%

These can only be regarded as approximate estimates and in the final modelling these values have been regarded as variable inputs, so that the sensitivity of the outcomes to changes can be easily investigated.

Estimated Activity for the Identified Hospitals

Table 5.3 shows the estimated activity (total inpatient plus day case episodes) at each selected hospital for the two driving time scenarios.

Table 5.3: Assignments of Total Episodes to Locations

Assignment of Episodes to Locations			
Congestion Locations	Episodes	SMOSS Locations	Episodes
Enniskillen	18493	Enniskillen	19195
Strabane	1603	Castledearg	1496
Omagh	9508	Omagh	12354
Londonderry	33603	Londonderry	33889
Magherafelt	2949	Magherafelt	2409
Coleraine	13114	Coleraine	13114
Ballycastle	680	Ballycastle	680
Ballymena	40080	Ballymena	41862
Armagh	2455	Dungannon	4740
Portadown	55759	Armagh	2873
Newry	12076	Newry	46622
Kilkeel	1195	Newcastle	1713
Lisburn	4359	Newtownabbey	7558
Belfast	134650	Belfast	162231
Carrickfergus	3274	Ballynahinch	8674
Downpatrick	8839	Newtownards	17296
Newtownards	31141		
Donaghadee	2928		
Totals	376706		376706
	Supplementary Assignments		
Portadown 1	40000	Belfast 1	45000
Portadown 2	15759	Belfast 2	45000
Belfast 1	45000	Belfast 3	45000
Belfast 2	45000	Belfast 4	27231
Belfast 3	44650		

The episodes shown in Table 5.3 cannot, of course, be directly weighted for casemix complexity. However, the relationship derived in a previous chapter between un-weighted episodes and the ratio of expected costs to actual costs, can be used to estimate these values.

The result of doing this gives an estimated average case complexity of around **77.7%** for the level-1 hospitals, **90%** for level-2 hospitals and **107.9%** for level-3 hospitals, (where NI as a whole = 100%),

Conclusions

Two 'theoretical' hospital scenarios (based on different assumptions concerning journey times) have been put together using an access modelling and activity modelling approach. The aim has been to apply the economy of scale costing to the hospitals in these scenarios and this application is covered in the next chapter.

The activity modelling has assumed that hospitals behave as 'typical' examples of Level 1, Level 2 or Level 3 type organisations respectively and does not (and cannot) reflect any special rules for the allocation of particular specialties to particular hospitals. Thus, for example, the model is not capable of reflecting the allocation of paediatrics to some level 2 hospitals and not to others.

CHAPTER 6: Applications of Hospital Scale Modelling: Theoretical Configurations

In relation to hospital EoS effects, previous chapters have described: scale cost modelling, an application of this modelling to the current hospital service provision, and the development of a more theoretical approach to hospital service provision based on access and activity modelling.

In this chapter the application of scale models to estimating the effects of the theoretical hospital configurations studied is described.

The main theoretical configurations explored are:

1. An access-driven theoretical configuration based on SMOSS default journey times
2. An access-driven theoretical configuration subject to congestion-weighted journey times

In both cases hospital activity has been derived from patient flows to hospitals classified according to the hierarchical model described in the chapter dealing with activity modelling. Hospitals are classified as levels 1, 2 or 3, where level 1 reflects local services, level 2 reflects intermediate services and level 3 reflects total services. A hospital at a particular level is assumed to carry out work appropriate to its level plus work associated with any levels below its designated level.

EoS Costs for the Access-Driven Configurations

Hospitals within the Boards

The main presentation here has used the scale function associated with Scenario B, as described earlier. The equation used for evaluating scale cost per 1000 episodes is:

$$\text{EoS cost per episode} = 0.2335 x^2 - 18.6201 x + 372$$

A maximum value of EoS per episode has been set a level associated with $x = 5$ (i.e. 5,000 episodes), to avoid extrapolating beyond the minimum level of activity used to build the cost model. The overall results in terms of the estimated scale costs associated with the hospitals operating within the four Boards are shown in Table 6.1.

Table 6.1: Scale Costs for Hospitals within Boards

Scale Costs for the Access Configurations		
	Congestion	SMOSS
Eastern	£5,553,239	£6,518,853
Northern	£4,202,126	£4,318,906
Southern	£5,412,913	£2,703,179
Western	£4,835,118	£5,548,666
	£20,003,395	£19,089,604

It should be noted that the total cost, in both cases, is significantly below the figure for the current pattern of service - **£35.7** 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.

It can be clearly seen that the pattern of costs is sensitive to the configuration of hospitals – in particular to the number of hospitals that happen to be located within each Board. The ‘benefit’ to the Southern Board of ‘losing’ one complete hospital (under SMOSS) is one example of this effect.

However, as in the analysis of the current service, the theoretical scenarios generate a considerable amount of cross-boundary flow and the effects of this must clearly be taken into account.

Apportioning the Costs to Boards

As in the analysis of the current service, the proportional flows to hospitals from the districts (and Boards) have been quantified. Because the Access Model – using a ‘nearest appropriate hospital’ rule – has generated the scale-cost modelled activity it is the flows predicted by this model that must be applied.

The results of apportioning the costs shown in Table 6.1 using the ‘shadow’ price method described in an earlier chapter gives the scale budgets and shares for the two access driven scenarios that are shown in Table 6.2.

Table 2: Scale Budgets for Boards – Access Scenarios

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	

The relative share of the scale budget remains sensitive to the configuration option considered. In particular, the balance between the Southern and Northern Boards appears to be affected by the different locations chosen under the two scenarios.

Interpretation

It is clear that both configurations yield 'shares' that are at variance with the current capitation shares: Eastern (42.16%), Northern (23.66%), Southern (17.67%) and Western (16.51%). However, it is particularly important to recognise that this theoretical approach is, in effect, only considering scale costs associated with hospitals that are below the optimum size. The scale cost modelling of NI hospitals, presented in an earlier chapter, suggests that diseconomies of scale might return as hospitals become very large but in this theoretical approach, such large hospitals are presumed to be avoidable.

Conclusions

The scale modelling methodology has been applied to three alternative hospital configurations:

- The Current pattern of Services
- The Access-Driven Theoretical Scenario – SMOSS Journey Times
- The Access-Driven Theoretical Scenario – Congestion Journey Times

In this presentation Scenario B has been used as the costing basis – critical care costs are included, excess bed day adjustments are made and excess bed days are costed at NHS relativities to total bed day costs. Other scenarios have also been explored but these have little effect on overall conclusions.

Overall the work has raised many questions. The main complexity of interpretation arises directly from the U-shaped relationship identified between hospital size and scale cost. In Northern Ireland this form of relationship arises mainly from the analysis of the costs and activities of one large hospital group. Although previous research by others does support the notion of an 'optimal' hospital size from the viewpoint of maximising the economic efficiency of a hospital, the evidence remains inconclusive.

Even if the U-shaped relationship is accepted and, hence, diseconomies of scale associated with large hospitals are to be expected, it is not clear whether such additional costs should be regarded as unavoidable in the sense meant in this research. The theoretical configurations, in which hospitals are restricted in their maximum size consistently show, not only reductions in differential scale costs overall, but a significant re-balancing

of such costs between the Health Board areas. Because the focus becomes that of smaller hospitals being unable to achieve sufficient capacity, areas where such hospitals are needed for access reasons show increased (and unavoidable) scale costs.

CHAPTER 7: Economy of Scale Effects in Northern Ireland Community Services

In this study activities and costs in the provision of community services in Northern Ireland have been explored:

1. To determine (or otherwise) whether there is evidence for EoS scale effects in community services
2. To identify and quantify such scale effects if they are present so that relevant scale costs for activities of different sizes can be estimated
3. To model a number of alternative community service configurations or scenarios in terms of access, activities and flows with a view to estimating overall scale costs
4. To attribute the EoS costs derived from (c) to Districts and Boards taking account of expected cross-boundary flows in each scenario.

This chapter deals with the methodology adopted for the evaluation of scale costs and the next chapter examines the potential funding implications of the modelling.

Introduction

The effect of population settlement patterns and rurality on the cost structures of community-based HSS provision in Northern Ireland was the subject of a previous research project for DHSSPS¹⁵. This previous study quantified the extra travel-related costs of provision in the relatively more rural and sparsely populated areas.

A related service characteristic was also recognised at the time of the previous study: that operational units – teams, health centres, field offices, ambulance stations, day centres etc. – in the more rural areas tended to be smaller in size. No attempt was made in this earlier study to assess whether or not this characteristic has scale-cost implications.

Although the size of fixed facilities varies between different areas, only a limited amount of analysis of potential scale effects associated with such facilities has been attempted in this research project. This is because (a) very often community services will share facilities with each other and sometimes with non-community services and (b) the apportionment of facility costs between such shared services would be very difficult. The only fixed-facility costing that has been attempted is for day centres.

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 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.

Access Standards for Community Services

The approach that has been taken to scale costing in relation to community services has been a theoretical one. This approach has been similar to the approach taken in relation to the access-driven hospital configurations described in an earlier chapter. However, unlike in the hospital service studies, no work has been done on the scale costs actually faced by currently supplied services. The main reason for this omission has been the unavailability of the relevant operational data that would allow such costs to be quantified.

Access Time Targets

There are a number of reasons why teams in more rural areas tend to be smaller in size. However, one of the more important factors is that the teams will need an operating base – health centre, ambulance station, and so on – that is reasonably accessible to service users residing within the catchment area. Often it is important for users to be within a reasonable access time of a centre because they might need to visit the centre themselves and also because the service provider (district nurse, midwife, etc.) might need to react efficiently and quickly to the need for domiciliary visits.

The precise nature of such accessibility considerations does differ between different services. Thus, for district nursing, for example, a critical characteristic might be the need to co-ordinate nursing activities with the

activities of general practitioners - whereas for an emergency ambulance service there are defined response time requirements for reaching critical incidents in the area. Whatever the precise reasons, it will not normally be acceptable or practical to centralise community services so that larger teams cover catchment areas of large geographical size.

For each of the nine community services explored, service access standards have been defined by the policy makers in terms of the proportions of each district's population that should be within a given target access time of the nearest appropriate source of service provision. These standards are shown in Table 7.1. Generally, the access criteria take the form – *for all districts* - that at least 95% of the population must be within a target travel time of their nearest service centre.

**Table 7.1: Access Standards for Community Services
 Catchment Populations**

Agreed Access Times (Minutes)	At District Level except Emergency Ambulances	
Emergency Ambulances	75% of Category A within 8 minutes (Boards)	
District Nursing	95% within ...	15
Health Visiting	95% within ...	15
Home Care Work		None Set
Day Centres	95% within ...	30
Occupational Therapy	95% within ...	30
Community Psychiatric Nursing	95% within ...	30
Child Care Social Work	95% within ...	30
Community Midwifery	95% within ...	30

In exploring the effects of access times it is necessary to quantify the relevant catchment populations associated with the service delivery 'centres'. As in the (theoretical) hospital studies, described earlier, a simplistic rule has been used that the population will make use of the 'nearest' appropriate service.

This allocation of populations to centres is not consistent with current practice in the administration of community services on the ground in Northern Ireland – where service providers and users do not cross Board or Trust boundaries. However, in agreement with the Steering Group, we have not reflected such administrative constraints in the modelling. To do so would be inconsistent with the theoretical approach being taken.

Different 'relevant' populations are needed for each of the community services studied. Thus, for example, the relevant population for the midwifery service is mainly females of childbearing age, whereas, for home care services, it is mainly the elderly. To derive these populations the age/sex populations from the 2001 census have been used, weighted using the same weights that were used in the Rurality costing project.

A different approach, however, was taken for emergency ambulance services where the catchment areas are used to estimate annual incident rates using research carried out for the recently completed Strategic Review of Emergency Ambulance Services in the Province.

Access and Activity Modelling

Theoretical Service Configurations

Based on the access criteria for each service, an access model was used to determine a service configuration that minimised the number of locations needed to meet the targets set. A service configuration comprises a set of centres, including details of the geographical locations and attracted catchment populations.

As with the hospital services access, described earlier in this report, the model uses either so-called SMOSS journey times or congestion-weighted journey times, from all enumeration districts in Northern Ireland to any feasible service locations. The heuristic procedure used to determine each service configuration starts with all possible locations included, and methodically removes locations until the required access standard is breached.

The total set of possible locations was restricted to those cities/towns/villages currently providing at least a main general practice service (circa 100 locations).

The locations emerging from this modelling were subjected to a judgemental phase with the policy makers, where modifications were made aimed at improving the scenario particularly in relation to issues regarding acceptable levels of workload. Proposed centres attracting very low volumes were occasionally removed (and demand re-assigned to the nearest remaining centres) and, especially in Belfast, large volume centres were often further sub-divided.

Estimating the Workload at each Location

The Nature of the Workload

The estimated catchment populations, combined with normative demand rates for each service, have been used to estimate the expected number of demands per working day arising from each enumeration district, and, via the access model, the numbers assigned to the service centres. Due to the timing of this work, 2001 Census populations were available and used (backfilled to ED-level) for both access and demand modelling.

These normative demand rates were taken directly from values quoted in the Rurality Study for Northern Ireland. However, despite the fact that

these demands have been appropriately weighted they cannot be regarded as satisfactory indicators (for scale costing purposes) of the relative sizes of the operational units/centres. This difficulty arises because of the confounding effects of travel-related activities.

Thus, for example, if a district nursing service in a given location (A) faces precisely the same level of weighted demand as one in another location (B), the relative workloads might still be quite different, depending on the geographical characteristics of the areas served. Both services will provide domiciliary visiting and, if location A serves a much more rural and dispersed community than does location B, the travel distances and times are likely to be greater and, hence, the effective workload is greater: fewer visits can be done per staff member per day, more distinct tours of duty might be required, repeat visiting to an individual patient more time-expensive and so on.

Thus, the appropriate measure of activity for most community services must combine measures of weighted demand and measures of travel-related effects. In other words, staff time, in dealing with the workload, is a combination of time spent directly with the client and time spent travelling – whether this is domiciliary visiting, gathering clients for day centres, responding to emergency incidents and so on.

Estimating Relative Staffing Levels

The method used for assessing staffing levels has made use of the modelling approach previously used for the Rurality Study. This methodology makes use of the expected spatial distribution of demands on a 'travelling' service together with simplified models of the routing, scheduling and delivering of the service, particularly to estimate the key outputs – travelling times.

It is important to note that the researcher has made use of an upgraded version of this package not in the possession of the DHSS&PS, whose version is out of date in terms of the populations used (1991 census), in terms of the underlying mathematical models and the GIS database used

Travelling times, when combined with other times such as administrative times, contact/visiting times, getting-going times between calls, etc, provides estimates of the expected total time required to meet the predicted workloads. It is this estimated total time that can provide a reasonably consistent basis for assessing the relative levels of staffing required between the centres.

It is very important to note that these estimated staffing levels are 'relative staffing levels' and not estimates of the numbers of actual FTE staff required.

Scale Effects Modelling

Background

The approach taken is very much in line with common-sense observations that small average volume activities will find it more difficult to cope with variability in demand than will high average volume activities. Also variations in supply capacity (due to sickness, holidays etc) will be harder to cope with. In other words, the 'slack' that is needed to cope with variability is proportionately greater in the low average volume situation.

If the demand and associated workload on a service from day to day shows very little variability, it is feasible (and sensible) to staff the activity at a level that is appropriate to this average workload. Also if workload is highly predictable then, even if it varies from day to day, it is often possible to schedule the available staff appropriately to match the work required. On the other hand if the service is highly variable and unpredictable, this approach to manning is infeasible. An obvious example of this effect is in the manning of emergency ambulances – where a 24-hour responsiveness is required irrespective of the average incident rate.

Evidence for the effects being modelled is available from a recent research study carried out for the County Councils Network in England¹, in which it was observed that the utilisation of day centre vehicles (and their drivers) was lower in situations where attendance volumes were relatively low than it was in high volume situations. Low utilisation was reflected both in a lower than average number of clients per gathering run and in the proportion of idle time. .

A simple indicator that reflects the effects of demand variability on utilisation is:

$$\text{Utilisation} = \text{Average Daily Demand} / \text{Planned Daily Demand}$$

Where the planned daily demand reflects a level above the average level that needs to be planned for because of daily variability.

The assumption here is that if the variability is very low, the planned level will be close to the average level and utilisation will be close to 100%. On the other hand (as for emergency ambulances) if some days are unpredictably busy, the planned level might need to be much higher than the average value, otherwise the busy day will result in failures to respond effectively. Thus, for example, in the Strategic Review of Emergency Ambulances, it was found that the utilisation of manned ambulance units at some stations could be as low as 20%.

A statistical model that can be used for estimating the required 'planned for' demand is:

$$PD = AD + ((\sqrt{AD \cdot k}) \cdot s)$$

Where:

PD = the Planned level of Demand

AD = the average level of Demand

k = the proportion of demand that is subject to random variability

s = the number of standard deviations of variable demand to be covered

This model is based on the assumption that the proportion of demand that is unpredictable will be a random variable following the Poisson distribution and the variance will equal the mean. The standard deviation is the square root of the variance and, hence, if it is planned that one standard should be covered, the additional planned demand will be the square root of the variable demand. The value of *s* is regarded as a policy input.

As an example, if an ambulance unit faces an average incidence rate of 1.5 per day, and all demands are regarded as randomly occurring and the plan is to cover two standard deviations, the planned demand is as follows:

$$PD = 1.5 + (1.225 \times 2) = 3.95 \text{ demands per day}$$

Using the indicator of utilisation described above gives a value of $1.5/3.95 = 38\%$.

In order to assist in making estimates of the required parameters for each of the services studied a questionnaire survey was carried out by DHSSPS seeking the judgements of staff on the extent of variability in daily demand levels and the degree to which this was unpredictable for the service in which they worked.

Application of the Approach

The Steps

The operational modelling described above was applied to each of the services under consideration.

The initial step was to use the models to estimate the relative staffing requirements at each location on the basis of the direct workload associated with meeting average daily demand plus the travel-related workload. This combined effect was estimated in terms of the (average) total working time required to carry out the work. Dividing this total time by the time available per full-time worker gives a relative staffing requirement.

The second step involved using the utilisation indicator – as described above. Dividing the relative staffing requirement by the expected utilisation achievable yields a new estimate of the additional staffing requirement needed because of the failure (for whatever reason) to maintain full utilisation.

The final step was to cost the additional staffing requirement. The results produced by the modelling are not actual required staffing numbers but are intended as relative staffing requirements between the locations. However, information from the Workforce Census in Northern Ireland can be compared with the estimates produced by the modelling exercise. It proved difficult to obtain strictly comparable data, but generally the results appeared to match reasonably well. Hence, it was decided to use the average grade annual salary as a multiplier of the additional scale-related staffing as an estimate of the required cost. Further work is needed to improve this estimation method and, hence, the average salary has been included as an input to the models for each service so that these can be easily changed when better information becomes available.

Input Assumptions

A range of judgements from policy makers is inherent in reaching conclusions from this study of community services. Hence, the three main models used in this Community Services Study – the access model, the operational model and the scale effects model – have all been designed to form an interactive decision support system (within Excel) so that decision makers can explore the likely consequences of their own judgements concerning the various input values.

The scale-effects models, in particular, require informed judgements especially in relation to the appropriate values for parameters reflecting the degree of unpredictable variability in providing a service, the degree to which variability should be planned for, and the appropriate notional salary cost for estimated scale-related staffing.

Whilst these models allow for differing judgements on key inputs, we have nevertheless attempted within this study to get as close as possible to an agreed set of values so that, amongst other things, the possible differences in scale costs between locations can be assessed.

Conclusions

The application of the approach described in this chapter, using recommended values for key inputs, is described in the following chapter – along with the resulting estimated scale cost effects for the locations studied and, via cross-boundary analysis, on relevant administrative areas.

It can be seen from the above discussions that the methodology has focussed on the staffing effects associated with coping with variability in daily workload. Only in relation to day centres (described in the next chapter) have any fixed-facility effects been investigated.

Chapter 8: Application of EoS Costing to Community Services

In this chapter the application of the methodology described in the previous chapter for the scale costing of selected community services is described. Also the extrapolation of these results to other community services that have not been modelled is also described.

Introduction

Inputs, data, and results for each of the community services modelled are covered in the following order:

- Child Care Social Work
- Community Midwifery
- Community Psychiatric Nursing
- Day Centres
- District Nursing
- Emergency Ambulances
- Home Care Workers
- Health Visiting
- Community Occupational Therapy

As described in the previous chapter, an 'access model' was used to generate a theoretical configuration for each service - i.e., the number and location of the delivery points - based on access 'rules' agreed with the Project Steering Group. Subsequently, an operational modelling approach was used to estimate workload and relative staffing requirements at each selected service location based on normative demand rates and a range of other relevant input variables. .

A dynamic Excel model has been constructed to bring together the results of both the access and operational modelling, and to estimate the EoS costs for each location and, via cross-boundary flow analysis, these costs at Board level. The input variables used as the basis of the results for each service are listed in the relevant 'input tables'

For both access and demand modelling, 2001 census population figures were available and used (backfilled to ED-level)

The Scenarios for Each Service

The key features of the scenarios that have been costed for each service are described here. A similar template has been used for each service to facilitate comparisons.

Child Care Social Work

Social work professionals operating in Field Office-based teams deliver this service. These teams will differ in size. The component of the activity that has been modelled is the daily visiting by social work professionals to the homes of children and their families.

Access Criteria

The Steering Group set a target that 95% of all District populations should reside within 30 minutes driving time of the nearest field office.

Volume Criteria

No formal sustainability limits were set on catchment populations or team workloads at the initial access modelling stage. However a number of modifications were subsequently made to the locations emerging from the access modelling. Introducing a maximum weighted total catchment population size of 150,000 led to additional Field Offices being added at several locations and one small office was removed for sustainability reasons on the advice of the Steering Group.

Population Basis for Demand Estimation

The population basis used for determining the catchment populations has been the 2001 census populations for enumeration districts weighted by the age/sex balance for Northern Ireland as a whole for this service and the overall demand rate per head has been that used in the Rurality project.

Type of Scale Effects Estimated

The only scale effects considered have been those associated with the relative staffing levels at each location predicted from the operational modelling.

The Cost Model Inputs

The cost model uses the following input variables – average time at visit, average getting going time, average daily time available for FT child care social worker for visiting activities, NI average demand rate per day,

annual cost of an average grade child care social worker, proportion of daily demand that is subject to random daily variability and the number of standard deviations (above the average random demand) that the service should be able to deal with.

Table 8.1 shows the input variables used for this service, and the specific values of each variable used to generate the scale-cost results.

Table 8.1: Child Care Social Work – Input variables in model & values used

Input Variable	Value
Average Time at Visit	40 minutes
Average Getting Going Time	3 minutes
Daily Time Available	240 minutes
NI Daily Demand Rate	0.0007/ Head of Wt.Pop
Annual Cost of CCSW	£26,151 p.a.
Proportion of Variable Demand	0.5
Standard Deviations to Cover	1

Community Midwifery

Community midwifery teams operating from locality-based field offices to deliver this service. These teams will differ in size, and the component of the activity that has been modelled is domiciliary visiting to mothers and babies.

Access Criteria

The Steering Group set a target that 95% of all District populations should reside within 30 minutes driving time of the nearest field office.

Volume Criteria

No formal limits were set at the initial access modelling stage. However, a maximum relevant weighted population size of 50,000 led to added Field Offices at several locations. Any centre attracting less than 10 visits per day was omitted and its demand transferred to the nearest appropriate location.

Population Basis for Demand Estimation

The population basis used for determining the catchment populations has been the number of females aged 15-44 years in each enumeration district and the overall demand rate per head has been that used in the Rurality project.

Type of Scale Effects Estimated

The only scale effects considered have been those associated with the relative staffing levels at each location predicted from the operational modelling.

The Cost Model Inputs

The cost model uses the following input variables – average time at visit, average getting going time, average daily time available for FT community midwife for visiting activities, NI average demand rate per day, annual cost of a weighted community midwife, proportion of daily demand that is subject to random daily variability and the number of standard deviations (above the average random demand) that the service should be able to deal with.

Table 8.2 shows the input variables used for this service, and the specific values of each variable used to generate the results.

Table 8.2: Community Midwifery – Input variables in model & values used

Input Variable	Value
Average Time at Visit	35 minutes
Average Getting Going Time	3 minutes
Daily Time Available	240 minutes
NI Daily Demand Rate	0.0024437/ Head of Wt.Pop
Annual Cost of CPN	£26,812 p.a
Proportion of Variable Demand	0.4
Standard Deviations to Cover	1

Community Psychiatric Nursing

Community psychiatric nursing teams operating from locality-based field offices deliver this service. These teams will differ in size, and the important component of the activity that has been modelled is domiciliary visiting to mental health clients.

Access Criteria

The Steering Group set a target that 95% of all District populations should reside within 30 minutes driving time of the nearest field office.

Volume Criteria

No formal limits were set at the initial access modelling stage but a maximum weighted population size of 150,000 led to added Field Offices

at several locations and a number of small Offices were combined in the southwest.

Population Basis for Demand Estimation

The population basis used for determining the catchment populations has been the census populations for enumeration districts weighted by the age/sex balance for Northern Ireland as a whole for this service and the overall demand rate per head has been that used in the Rurality project.

Type of Scale Effects Estimated

The only scale effects considered have been those associated with the relative staffing levels at each location predicted from the operational modelling.

The Cost Model Inputs

The cost model uses the following input variables – average time at visit, average getting going time, average daily time available for FT community psychiatric nurse for visiting activities, NI average demand rate per day, annual cost of a weighted community psychiatric nurse, proportion of daily demand that is subject to random daily variability and the number of standard deviations (above the average random demand) that the service should be able to deal with.

Table 8.3 shows the input variables used for this service, and the specific values of each variable used to generate the scale cost results.

Table 8.3: Community Psychiatric Nurses – Input variables in model & values used

Input Variable	Value
Average Time at Visit	45 minutes
Average Getting Going Time	3 minutes
Daily Time Available	200 minutes
NI Daily Demand Rate	0.00036 per Head of Wt.Pop
Annual Cost of CPN	£25,327 p.a.
Proportion of Variable Demand	0.4
Standard Deviations to Cover	1

Day Centres

Two components of this service have been modelled – the activities within the centres and the transporting of clients to and from these centres.

Access Criteria

The Steering Group set a target that 95% of all District populations should reside within 30 minutes driving time of the nearest day centre.

Volume Criteria

No formal limits were set at the initial access modelling stage but a maximum population size of 120,000 gave added Day Centres at several locations and some smaller Day Centres were combined in three districts.

Population Basis for Demand Estimation

For this service the catchment populations were derived from total enumeration district populations. However demands were estimated for the four care groups separately – elderly, mental illness, sensory disability and learning disability using the ED populations weighted for the age/sex balance of client demand for the four care groups separately for Northern Ireland as a whole. Demand rates per head of weighted population for each care group is the same as for the Rurality Study.

Type of Scale Effects Estimated

Two different scale cost effects were estimated for this service – the fixed facility effects and the manning levels for vehicles used for client gathering.

Cost Model Inputs

The cost model uses the following input variables – average time at pick up/put down, average getting going time, average daily time available for client gathering activities, NI average demand rate per day, proportion of demand needing transport, annual cost of a vehicle team, fixed and variable annual costs of staffing day centres, the fixed annual cost of vehicle operation, proportion of daily demand that is subject to random daily variability and the number of standard deviations (above the average random demand) that the service should be able to deal with.

Table 8.4 shows the input variables used for this service, and the specific values of each variable used to generate the scale-cost results.

Table 8.4: Day Centres – Input variables in model & values used

Input Variable	Values	
Average Time at Pick Up/Put Down	5 minutes	
Average Getting Going Time	3 minutes	
Daily Time Available for	200 minutes	

Gathering		
NI Daily Demand Rate	.0013 per Head of Wt.Pop (Combined)	
Transport Proportion	0.8	
Annual Cost of Vehicle Team	£22,072 p.a.	
	Fixed	Variable (per client)
Day Centre Staff (MH)	£97,257	£5,798
Day Centre Staff (PD)	£84,851	£6.665
Day Centre Staff (LD)	£97,257	£5.798
Day Centre Staff (E)	£51,995	£4,641
Annual Vehicle Fixed Cost	£1,000	
Proportion of Variable Demand	0.5	
Standard Deviations to Cover	1	

It should be clearly noted from Table 8.4 that there is both a fixed and variable cost element to the modelling. This is specifically included to compensate for 'establishment cost' in addition to size related costs – meaning that the compensation for operating two separate facilities (necessitated for example in a sparsely populated area to meet access standards) will be substantially greater than operating one facility catering to the same aggregate demands.

District Nursing

This service is delivered by district nursing teams linked to Health Centres and large GP practice. These teams will differ in size. The component of the activity modelled is domiciliary visiting.

Access Criteria

The Steering Group set a target that 95% of all District populations should reside within 15 minutes driving time of the nearest health centre.

Volume Criteria

No formal limits were set at the initial access modelling stage but a maximum population size of 50,000 led to added Health Centres at several locations.

Population Basis for Demand Estimation

Locations were derived using the total ED populations attracted but demand levels were estimated using the age/sex balance of district nurse visiting for Northern Ireland as a whole. Demand Rates per head have been those used in the Rurality Study.

Type of Scale Effects Estimated

The only scale effects considered have been those associated with the relative staffing levels at each location predicted from the operational modelling.

The Cost Model Inputs

The cost model uses the following input variables – average time at visit, average getting going time, average daily time available for FT district nurse for visiting activities, NI average demand rate per day, annual cost of a weighted district nurse, proportion of daily demand that is subject to random daily variability and the number of standard deviations (above the average random demand) that the service should be able to deal with.

Table 8.5 shows the input variables used for this service, and the specific values of each variable used to generate the scale cost results.

Table 8.5: District Nursing – Input variables in model & values used

Input Variable	Value
Average Time at Visit	25 minutes
Average Getting Going Time	3 minutes
Daily Time Available	300 minutes
NI Daily Demand Rate	0.003 per Head of Wt.Pop
Annual Cost of DN	£21,106 p.a.
Proportion of Variable Demand	0.5
Standard Deviations to Cover	1

Emergency Ambulances

This service operates from ambulance stations, and is provided by operating fleets covering ambulance-operating patches. These fleets will differ in size. The major component of the activity that has been modelled is the manning levels associated with emergency and urgent response and delivery to A&E (if required).

Access Criteria

The access and response time standards used are those set out in the recent Strategic Review of Northern Ireland Ambulance Service.

Volume Criteria

No formal limits have been set.

Population Basis for Demand Estimation

For this service the locations used have been those recommended in the strategic review and demands have been based not on populations but on the surveyed patterns of emergency and urgent incidents in NI.

Type of Scale Effects Estimated

The only scale effects considered have been those associated with the relative manning levels at each location predicted from the operational modelling.

The Cost Model Inputs

The cost model uses the following input variables – average time ‘on scene’, average activation time, average time at A&E per incident, forecast demand rates per day in districts and operating areas, annual cost of a 24-hour emergency ambulance, proportion of daily demand that is subject to random daily variability and the number of standard deviations (above the average random demand) that the service should be able to deal with.

Table 8.6 shows the input variables used for this service, and the specific values of each variable used to generate the scale-cost results.

Table 8.6: Emergency Ambulances – Input variables in model & values used

Input Variable	Value
Average Time ‘On Scene’	20 minutes
Average Activation Time	3 minutes
Average Time at A&E	25 minutes
Daily Demand Rates	Forecasted
Annual Cost of 24-hour Ambulance	£322,000 p.a
Proportion of Variable Demand	0.75
Standard Deviations to Cover	2

Home Care Workers

Individual workers operating from their own homes provide this service. However, ‘patches’ are formed by groups of workers and these teams will differ in size. The component of the activity that has been modelled is domiciliary visiting.

Access Criteria

No access criteria have been used in modelling this service – it has been assumed that all clients are accessible to an appropriately located home care worker.

Volume Criteria

No formal volume criteria have been set – the method used for determining the number of patches needed in each district has been based on empirical studies of patch organisation in England, carried out for the County Councils Network. This work in North Yorkshire showed that patch numbers were dependent on both population and sparsity. A regression model derived from these data has been applied to the Northern Ireland districts from census data and area sizes.

Population Basis for Demand Estimation

In the absence of specific home care data, the ED populations weighted for the district nursing (thought to be similar in client characteristics) age/sex balance of visiting for Northern Ireland as a whole has been used. The demand rates for home care per head of this weighted population has been derived from English information, and agreed with the Steering Group.

Type of Scale Effects Estimated

The only scale effects considered have been those associated with the relative staffing levels at each location predicted from the operational modelling.

The Cost Model Inputs

The cost model uses the following input variables – average time at visit, average getting going time, average daily time available for FT home care worker for visiting activities, NI average demand rate per day, annual cost of a home care worker, proportion of daily demand that is subject to random daily variability and the number of standard deviations (above the average random demand) that the service should be able to deal with.

Table 8.7 shows the input variables used for this service, and the specific values of each variable used to generate the scale-cost results.

Table 8.7: Home Care Workers – Input variables in model & values used

Input Variable	Value
Average Time at Visit	120 minutes
Average Getting Going Time	3 minutes

Daily Time Available	300 minutes
NI Daily Demand Rate	0.06 per Head of Wt.Pop.
Annual Cost of HCW	£19,000 p.a.
Proportion of Variable Demand	0.2
Standard Deviations to Cover	1

Health Visiting

Health visitors working in teams linked to Health Centres and large GP practice deliver this service. These teams will differ in size. The component of the activity modelled is domiciliary visiting.

Access Criteria

The Steering Group set a target that 95% of all District populations should reside within 15 minutes driving time of the nearest health centre

Volume Criteria

No formal limits were set at the initial access modelling stage but a maximum population size of 50,000 led to added Health Centres at several locations and some smaller Health Centres were combined in the south west of NI.

Population Basis for Demand Estimation

Health centres were located using the total populations of the enumeration districts but demand levels were estimated from the ED populations weighted for the age/sex balance of health visiting for Northern Ireland as a whole. The demand rates per head of weighted population have been modified from those used in the Rurality Study, in light of advice from the service

Type of Scale Effects Estimated

The only scale effects considered have been those associated with the relative staffing levels at each location predicted from the operational modelling.

The Cost Model Inputs

The cost model uses the following input variables – average time at visit, average getting going time, average daily time available for FT health visitor for visiting activities, NI average demand rate per day, annual cost of a weighted health visitor, proportion of daily demand that is subject to random daily variability and the number of standard deviations (above the average random demand) that the service should be able to deal with.

Table 8.8 shows the input variables used for this service, and the specific values of each variable used to generate the scale-cost results.

Table 8.8: Health Visiting – Input variables in model & values used

Input Variable	Value
Average Time at Visit	35 minutes
Average Getting Going Time	3 minutes
Daily Time Available	240 minutes
NI Daily Demand Rate	.0015 per Head of Wt.Pop
Annual Cost of HV	£27, 421 p.a
Proportion of Variable Demand	0.3
Standard Deviations to Cover	1

Community Occupational Therapy

This service operates from Field Offices, and is delivered by community OT teams. These teams will differ in size. The component of the activity modelled is domiciliary visiting.

Access Criteria

The Steering Group set a target that 95% of all District populations should reside within 30 minutes driving time of the nearest field office

Volume Criteria

No formal limits were set at the initial access modelling stage but a maximum relevant weighted population size of 50,000 led to added Field Offices at several locations. Any centre attracting less than 10 visits per day was omitted and its demand transferred to the nearest appropriate location. However one site – Portavogie – was re-instated because the effects of its removal on access were too great to accept.

Population Basis for Demand Estimation

ED populations have been weighted for the age/sex pattern of demand for OT services found in NI as a whole. The demand rate per head of weighted population is the same as that applied in the Rurality Study.

Type of Scale Effects Estimated

The only scale effects considered have been those associated with the relative staffing levels at each location predicted from the operational modelling.

The Cost Model Inputs

The cost model uses the following input variables – average time at visit, average getting going time, average daily time available for FT community occupational therapist for visiting activities, NI average demand rate per day, annual cost of a weighted community occupational therapist, proportion of daily demand that is subject to random daily variability and the number of standard deviations (above the average random demand) that the service should be able to deal with. Table 8.9 shows the input variables used for this service, and the specific values of each variable used to generate the scale cost results.

Table 8.9: Community Occupational Therapy – Input variables in model & values used

Input Variable	Value
Average Time at Visit	30 minutes
Average Getting Going Time	3 minutes
Daily Time Available	300 minutes
NI Daily Demand Rate	0.002942 per Head of Wt.Pop
Annual Cost of CPN	£23,968 p.a.
Proportion of Variable Demand	0.5
Standard Deviations to Cover	1

Scale Costing Results

Overview

Each of the scenarios outlined above has an interactive scale-costing model associated with it. Each model initially derives a scale-related cost for each of the centres or locations based on either SMOSS journey times or congestion weighted journey times. The models also estimate the flows from Districts to each location and, using the 'shadow' pricing approach described in the chapters on hospital scale costing, derive a District scale cost that, by aggregation, yields a Board level cost. The series of Tables below show the results at Board level for each service in turn.

Board Level Results

Table 8.10: Child Care Social Work

Board	SMOSS Locations	Congestion-Weighted Locations
East	£177,563	£189,217
North	£153,425	£161,322
South	£111,309	£128,172
West	£125,669	£131,635
Total	£567,966	£610,347

Table 8.11: Community Midwifery

Board	SMOSS Locations	Congestion-Weighted Locations
East	£113,324	£118,183
North	£100,187	£104,579
South	£68,912	£80,994
West	£82,788	£81,453
Total	£365,211	£385,208

Table 8.12: Community Psychiatric Nursing

Board	SMOSS Locations	Congestion-Weighted Locations
East	£162,028	£192,457
North	£133,168	£135,202
South	£93,177	£101,156
West	£98,859	£92,176
Total	£487,232	£520,992

Table 8.13: Day Centres

Board	SMOSS Locations	Congestion-Weighted Locations
East	£354,153	£462,534
North	£308,513	£440,053
South	£288,527	£345,535
West	£254,803	£330,050
Total	£1,205,996	£1,578,173

Table 8.14: District Nursing

Board	SMOSS Locations	Congestion-Weighted Locations
East	£314,450	£336,869
North	£234,321	£262,461
South	£166,554	£169,928
West	£177,147	£180,281
Total	£892,471	£949,539

Table 8.15: Emergency Ambulances

Board	Strategic Locations
East	£733,743
North	£801,915
South	£465,901
West	£513,925
Total	£2,515,483

Table 8.16: Home Care Workers

Board	SMOSS Locations	Congestion-Weighted Locations
East	£1,615,869	£1,628,427
North	£1,250,514	£1,257,199
South	£841,510	£845,109
West	£791,571	£791,095
Total	£4,499,464	£4,521,830

Table 8.17: Health Visiting

Board	SMOSS Locations	Congestion-Weighted Locations
East	£372,870	£406,375
North	£297,941	£335,805
South	£220,447	£226,263
West	£228,934	£233,094
Total	£1,120,192	£1,201,537

Table 8.18: Community Occupational Therapy

Board	SMOSS Locations	Congestion-Weighted Locations
East	£89,034	£90,588
North	£77,294	£78,081
South	£58,247	£58,610
West	£62,604	£62,227
Total	£287,177	£289,506

Table 8.19 below shows the combined results for modelled services. These combined results are simply obtained by adding the individual service results together. Each Board's share of the total amount is also shown.

Table 8.19: Combined Results Across all Services Modelled

Board	Scale Cost SMOSS	Share	Scale Cost Congestion	Share
Eastern	£3,908,183	32.73%	£4,133,472	32.88%
Northern	£3,391,626	28.40%	£3,611,167	28.72%
Southern	£2,292,431	19.20%	£2,399,428	19.08%
Western	£2,348,953	19.67%	£2,428,549	19.32%
Totals	£11,941,193		£12,572,616	

Although the modelled services are likely to reflect the general nature of all community services reasonably well and, hence, the expected 'sharing' of scale costs between Boards, the work carried does not provide directly an estimate of the total scale budget. Unlike in the hospital service modelling where total costs have been modelled, this is not the case for community services. Hence, an attempt has been made, described below, to extrapolate the results obtained to the total community service activity.

Extrapolation

Introduction

The nine community services modelled in detail were selected both because they display different service delivery characteristics and because of their overall costliness.

Three basic types of service were modelled viz., domiciliary visiting services, day centre services and emergency response services. Table 8.20 below lists the services selected by service type.

Table 8.20: Categories and services modelled in detail

Service Type	Services Selected
Domiciliary Visiting	Home Care Working District Nursing Health Visiting Community Psychiatric Nursing Community Midwifery Occupational Therapy Child Care Social Work
Day Centre Services	Elderly Clients Mental Health Clients Physically and Sensory Disabled Clients Learning Disability Clients
Emergency Response Services	Emergency Ambulances

Key factors present in these modelled services that appear likely to influence scale costs are:

- the total costliness of the service;
- the degree of unpredictability of daily demands on the service;
- the access criteria set for the service;
- the way organisational units are defined;
- sustainability and/or volume requirements; and
- the nature of the facilities/resources involved.

It is clear that the EoS effects are not only different between the service type categories, but the range of services studied within the domiciliary visiting category shows that each service has its own particular characteristics – and no simple relationship is likely to fully explain the findings. However some overall statistical relationships are evident in the results.

Scale Related Staffing and Total Staffing

The proportion of scale-related staffing to total staffing from the operational modelling is related to the input values of the variability parameter for a given constant value of the standard deviation input.

A linear regression equation fitted to the relationship between the staffing ratio and the square root of variability is statistically significant and has an R^2 value of around 61%. Furthermore the staffing ratio is almost directly proportional to the input number of standard deviations for a given variability input level.

Using these results the staffing ratio can be predicted from:

$$\text{Ratio (scale-related staffing/total staffing)} = 0.1212 \times \sqrt{k \times s}$$

Where

k = the variability parameter for the service,

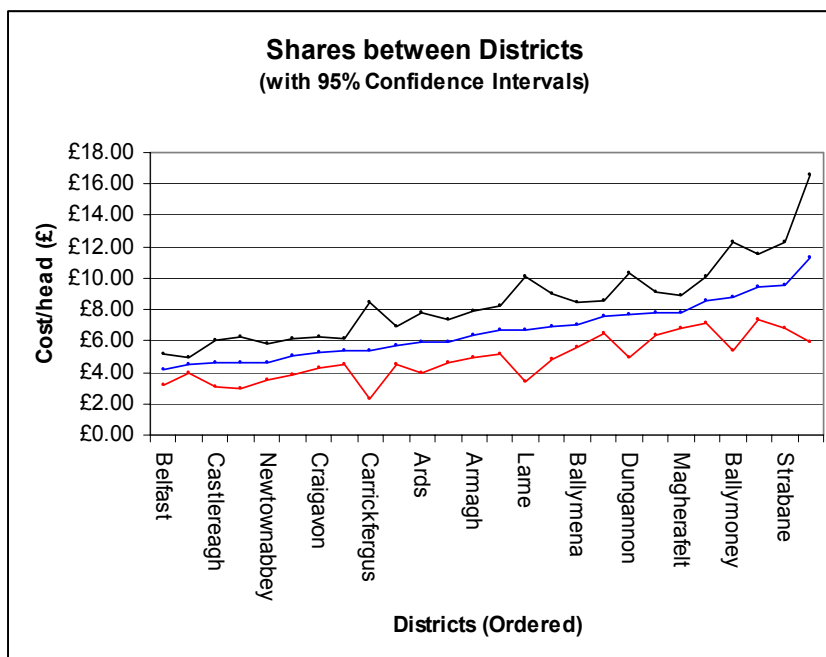
s = the number of standard deviations to be covered and

If the total relevant staffing costs of a service are known then the scale cost is easily estimated from the Ratio given above multiplied by this total staffing cost. This method is, of course, only relevant for estimating staffing-related effects and cannot be used for any other type of scale-related costing.

Sharing Costs between Districts

The variability between services in the predicted sharing of the scale costs between districts for the modelled services can be analysed. Figure 1 illustrates this variability by applying a notional budget of £10 million and obtaining the average cost per head for districts ordered from least to most 'expensive'. By obtaining the variance for each district between the services the 95% confidence intervals can be derived – as shown in Figure 8.1.

Figure 8.1: Shares of Cost per Head between (Ordered) Districts

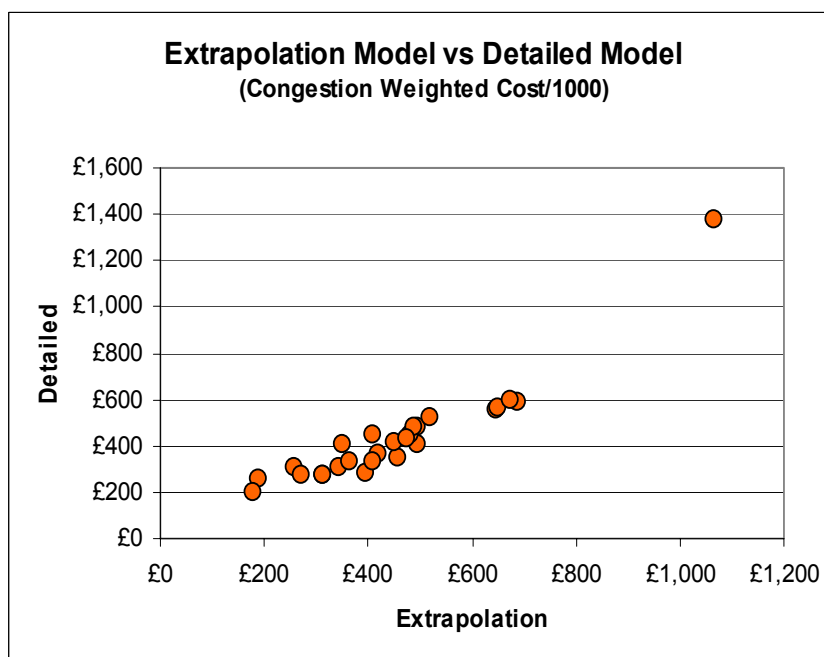


The coefficient of concordance (W) between the three lines for the rank ordering of districts is 89%, showing a highly significant degree of agreement. Although the lines show a tendency to become wider apart as costs increase, this trend is relatively weak and the general 'slope' of each line is similar. This high degree of concordance, taken together with the lack of clear gradient effects, suggests that using overall average values for extrapolation purposes are unlikely to give seriously biased results. However clearly this method must be seen as an approximation.

The Accuracy of the Generalised Model

A simple but feasible approximate method has been described for extrapolating the findings of the community services modelling studies to other services that have not been modelled in detail. As a test of this extrapolation model, it can be applied back to the findings from the detailed modelling of the nine services. Figure 8.2 shows the result of doing this using the congestion-weighted district EoS results. Costs have been divided by 1,000 to assist presentation.

Figure 2: Testing the extrapolation method against detailed model results



The relationship is clearly quite good with only Belfast (the largest cost district) being somewhat out-of-line. This effect is not as pronounced when SMOSS journey times are used and almost certainly arises from the extra sub-division of centres in the Belfast area needed to avoid unacceptably high activity volume centres.

Applying the Extrapolation Model

In order to apply the extrapolation method to new services, estimates of the proportions of demand that are subject to variability are required (as is the case for the modelled services) and also the total relevant annual staffing costs of the services are required. However, because of the generalised nature of the extrapolation model a single category of 'all non-modelled services' can be used for the extrapolation. The required variables are (a) the total annual relevant staffing cost of these services combined and (b) the demand-weighted average input variability.

Table 8.21 shows a list of these services, estimates of the variability parameter for each service, and the estimated total salary cost for the relevant front-line staff. The weighted average variability is also shown and the total annual cost estimates for all services.

These results assume that the policy input is one standard deviation in all cases. A number of estimates have been needed in order to generate the data in the above table. For each service, a guideline-modelled service (the modelled service most 'similar' to the service in question) has been

used together with guidance provided by the questionnaire survey on the degree of daily demand variability. The guideline services have also been used to estimate salary levels and, using the demand rates contained in the rurality studies, the likely numbers of front-line staff.

Table 8.21: Inputs to extrapolation model for non-modelled services

Inputs for Non-Modelled Services	Estimated Proportion Variable	Estimated Relevant Cost
Service		
Podiatry	0.5	£2,852,192
Elderly SW	0.4	£3,111,933
Mental Health SW	0.2	£2,118,207
Learning Disability SW	0.2	£732,220
Physical & Sensory Disability SW	0.2	£2,850,426
Community nurses	0.3	£1,055,300
Community medical	0.2	£527,650
Community learning disability nurses	0.3	£633,180
Speech therapy	0.3	£1,629,832
Physiotherapy	0.5	£3,691,072
Dietetics	0.3	£884,794
Community dental	0.2	£422,120
Day centres family & child care	0.4	£5,253,193
		£25,762,119
	Wt. Variability =	0.36

The extrapolation model has been applied using the two inputs of 0.36 for variability and £25.76 million for cost.

The results in terms of Board EoS costs are shown in the following Table (Table 8.22).

Table 8.22: Results of extrapolation

Result - Non-Modelled Services		
	SMOSS	Congestion
East	£559,818	£579,809
North	£535,294	£552,431
South	£382,252	£393,452
West	£396,058	£398,662
Totals	£1,873,421	£1,924,355

These results can be combined with results from the services modelled in detail, to give the overall EoS costs for all community services

Overall EoS Cost for Community Services

Table 8.23 shows the final estimates of scale costs for community services at Board level. These results are based on the following scenario:

- ◆ Day Centre costs include the costing of the facilities as well as the vehicle-related costs
- ◆ All inputs are as described in this chapter
- ◆ Extrapolated Costs are included

Table 8.23: EoS Costs for Boards for Community Services

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	

The Table shows the costs for SMOSS results and congestion-weighted results and the shares between Boards.

Conclusion

Scale costs have been estimated for Boards for Community Services. Largely these costs are based on the need to supply staffing to cope with variability in daily demands, which is differentially affected by the scale of activities. Furthermore only distributed travel-related services have been considered. Little attention has been given to the identification of possible scale costs associated with facility-based services or to fixed facilities of differing scale. The only exception to this has been the costing of day centre facilities.

Thus the costs identified are unlikely to be the total scale costs associated with the provision of these services but, nevertheless, are likely to represent a high proportion of such costs.