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Economies Of Scale In The General Hospital Industry

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ECONOMIES OF SCALE IN

THE GENERAL HOSPITAL INDUSTRY

by

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ABSTRACT

The purpose of this dissertation is to ascertain the extent and magnitude of scale effects in the general hospital industry. Two methods are suggested. First, scale effects are estimated using a "hotel-type" services model whereby services which differentiate one hospital from another are excluded from the analysis. The results indicate that the average cost curve is saucer shaped in the 300 to 500 bed range with marked upward trends at both ends.

In the second approach, multiple regression analysis is used to assess the importance of various factors, including size, that affect total hospital costs. The main results are as follows: (a) the optimum sized hospital is in the 300 to 500 bed range, (b) affiliation with a nursing school and/or a medical school results in an additional cost over and above that which the accountants have allocated, (c) an increase in the occupancy rate reduces the overall cost per diem, and (d) the casemix is significant in explaining inter-hospital cost variations.

In addition, scale effects were estimated at the departmental level. The results tend to support the conclusion reached above that the optimum sized hospital is in the 300 to 500 bed range.

In the light of the above research, the policy implication from the hospital administrator's point of view is to build hospitals in the 300 to 500

bed range. If this is not feasible and if departmental consolidations are, departments should be consolidated according to their respective optima.

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CHAPTER I

INTRODUCTION

The economic aspects of health services have been of concern for many years, yet the application of rigorous economic analysis to this field has been very limited.[1] Mushkin[2] has held that economists have paid little attention to the health field because medical services have special characteristics, such as the general absence of the profit motive, which mark them as exceptions to normal market behaviour. On the other hand, many health economists, including Lees,[3] have held that health services have no economic characteristics that differentiate them from other goods. For example, the conceptual problem of defining output and the problem of under-capacity utilization are much the same in the hospital industry as in other industries. These problems will be discussed at a later stage.

The purpose of this dissertation is to ascertain the magnitude and

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[1]For a summary of the various studies, see H. E. Klarman, The Economics of Health (New York: Columbia University Press, 1965), Ch. V.

[2]S. J. Mushkin, "Toward a Definition of Health Economics," Public Health Reports, LXXIII, No. 9, (1958), 6-7.

[3]D. S. Lees, Health Through Choice (London: Institute of Economic Affairs, 1961), pp. 19-21.

extent of scale effects in the hospital sector of the health services field. With the advent of provincial and national medicare in Canada, an increase in the demand for hospital services is to be expected. Consequently, enquiry into scale effects should prove to be useful because the existence of economies of scale would be an important determinant in the provision of hospital services to meet this increased demand.

General hospitals in the Province of Ontario were chosen as the object of the enquiry for several reasons. The first is that the sample is adequate both in terms of size and distribution (see Table 3, p.25). Second, detailed statistical information is available for every hospital in Ontario.[4] Finally, factor prices are more uniform in the Province of Ontario than they would be in a larger sample.

The paper's basic organization can be outlined as follows. In Chapter II, the theoretical framework of scale effects is first discussed. This is followed by a critical review of the existing literature on scale effects in the hospital industry. This evaluation then serves as the basis on which our study proceeds. In Chapter III, scale effects are estimated using a "hotel-type" services model whereby services which differentiate one hospital from another are excluded from the regression analysis. In Chapter IV, multiple regression analysis is applied to <u>total</u> hospital costs in order to assess the

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[4]This information is made available in a standardized form by the Ontario Hospital Services Commission, a central regulatory agency which controls the financial operations of all public hospitals in the Province of Ontario.

relative importance of various factors, including hospital size, that affect hospital costs. In Chapter V, scale effects are estimated at the departmental level. If, for some reason, optimum sized hospitals are not feasible and if departmental consolidations are, the estimated departmental cost functions will then enable us to determine the extent to which consolidations should take place. In Chapter VI, a summary and conclusions are presented.

CHAPTER II

THEORETICAL FRAMEWORK AND CRITICAL REVIEW OF THE LITERATURE

In Section I, a theoretical hypothesis concerning the relationship between costs and output is presented. In Section II, the existing literature on economies of scale in the hospital industry is critically evaluated; the evaluation then serves as the basis on which our study proceeds.

I. Theoretical Framework

Traditionally, the long-run average cost curve has been depicted as being U-shaped; that is, the average cost per unit decreases as output is increased but after a certain output is reached, the average cost begins to increase. The falling portion of the cost curve results from economies of scale whereas the rising portion is a result of diseconomies of scale. If average cost does follow this pattern, then the total cost curve has the shape illustrated in Figure I. According to Robinson, economies of scale can be explained by the following factors:

1. Division of Labour

    a. ... a man or woman who works continuously at one task for some time will acquire a skill or a knack of doing it which will not be shared by another, even naturally more skilful, who has not tackled that job before.

b. ... it is by securing the steady concentration of man and machine upon a single task that the division of labour achieves economy.

c. ... many of the small inventions which have done so much to simplify machinery, or to make it more nearly automatic, have been the work of operators who, during the hours of tending a machine ... have found a way of throwing yet another task on the machine itself.

2. The Integration of Processes

... two or three or more consecutive processes are performed by a more complicated machine, which thereby eliminates the labour and time required to set up the work on each of the successive earlier machines.

3. The Economy of the Large Machine

... when output has sufficiently increased one process which has hitherto been performed by a member of parallel workers may be taken over by a single machine ... an economy lies with those who can afford to employ it.

4. The Balance of Processes

... firm must be of such size that all these various units may be conveniently combined without any wastes from partially employed equipment.

5. Economies of Large Managements

... a large firm can obtain an economy because certain services do not have to be increased in the same ratio as the growth of the firm.[1]

Although advantages of mass production exist, they may not continue forever.

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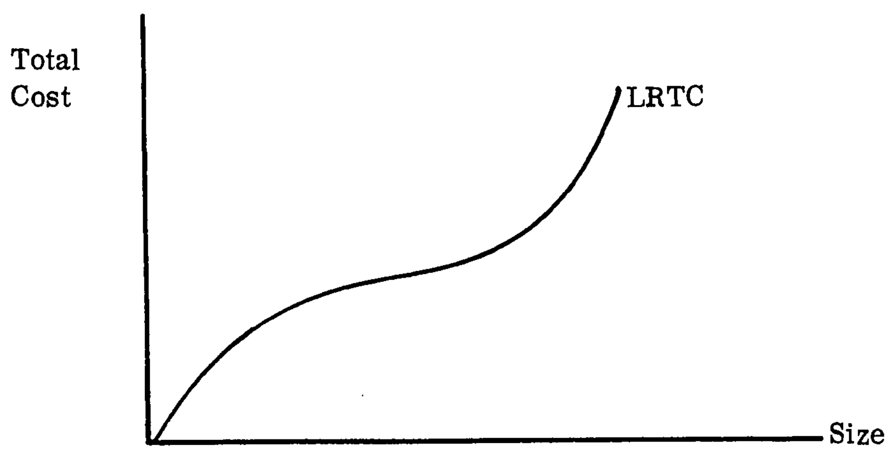
[1]E.A.G. Robinson, The Structure of Competitive Industry (London: Nisbet and Cambridge University Press,1953), pp. 20-45.

A point may eventually be reached beyond which an increase in size becomes a disadvantage. For example, after a certain size is reached, a further increase may result in a multifold increase in the complexity of management, due to red tape and loss of personal contact, which is not offset by a corresponding increase in enterpreneurial ability.

Figure I

Theoretical Relationship Between
Total Cost and Size of the Firm



In recent years, it has been argued, with growing documentation,[2] that economies of scale prevail over the entire size range. If this hypothesis is correct, then the average cost curve is L-shaped and the total cost curve has the shape illustrated in Figure II. Whether the curve is U-shaped or L-shaped is an empirical question to which we address ourselves in Chapters III and IV.

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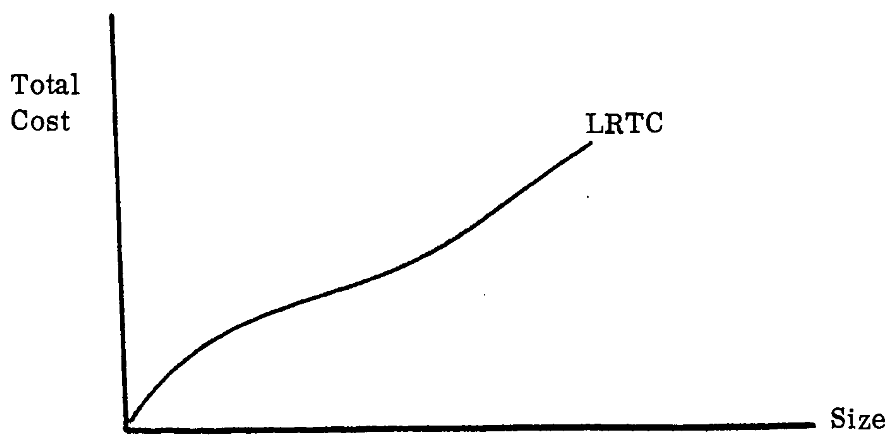
[2]For example, see J. S. Bain, Barriers to New Competition (Cambridge: Harvard University Press, 1965), and J. Johnston, Statistical Cost Analysis (New York: McGraw-Hill Book Company, 1960).

We now proceed to a critical evaluation of the existing literature on economies of scale in the hospital industry.

Figure II

Measured Relationship Between
Total Cost and Size of the Firm



II. A Critical Review of the Existing Literature

In this section, the various methods used to estimate economies of scale in the hospital industry are critically evaluated.[3] The evaluation then serves as the basis on which our analysis of hospital costs proceeds.

Using monthly data from the Methodist Hospital in Chicago, Feldstein[4] finds the short-run marginal cost curve to be less than average cost.

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[3]For an excellent review of the literature, see J. R. Lave, "A Review of the Methods Used to Study Hospital Costs," Inquiry, III (May 1966), 57-81.

[4]Paul J. Feldstein, An Empirical Investigation of the Marginal Cost of Hospital Services (Chicago: Graduate Program in Hospital Administration, University of Chicago, 1961).

In other words, the short-run average cost curve must be falling. He then argues that a declining short-run average cost curve can be interpreted theoretically in either one of two ways.

> The first case, when decreasing short-run average total costs imply excess capacity, is typified by a hospital operating on the rising portion of the long-run average cost curve. Such a plant is represented by the declining segment of ATC_3 ...
>
> On the other hand, if decreasing short-run average total costs do not imply excess capacity, they then suggest the existence of long-run increasing returns.[5]

In summary, a declining short-run average cost curve implies economies of scale only if the plant is operating at full capacity; otherwise, diseconomies of scale are implied. The problem then is to determine whether or not excess capacity exists. Given an occupancy rate of 90 percent, Feldstein concludes that "an average occupancy rate as high as this implies that there was little excess capacity."[6] From the previous analysis little excess capacity would seem to imply economies of scale. However, Feldstein qualifies his results in the following manner:

> ... in industries where marginal costs are a small portion of average total cost, all firms in the industry will have decreasing short-run average total costs until capacity is reached. If this were the situation among hospitals, i.e., all size hospitals have decreasing short-run average total costs, then evidence of a decreasing short-run average total cost curve from a single hospital would not enable us to make any inferences as to the evidence of long-run increasing returns.

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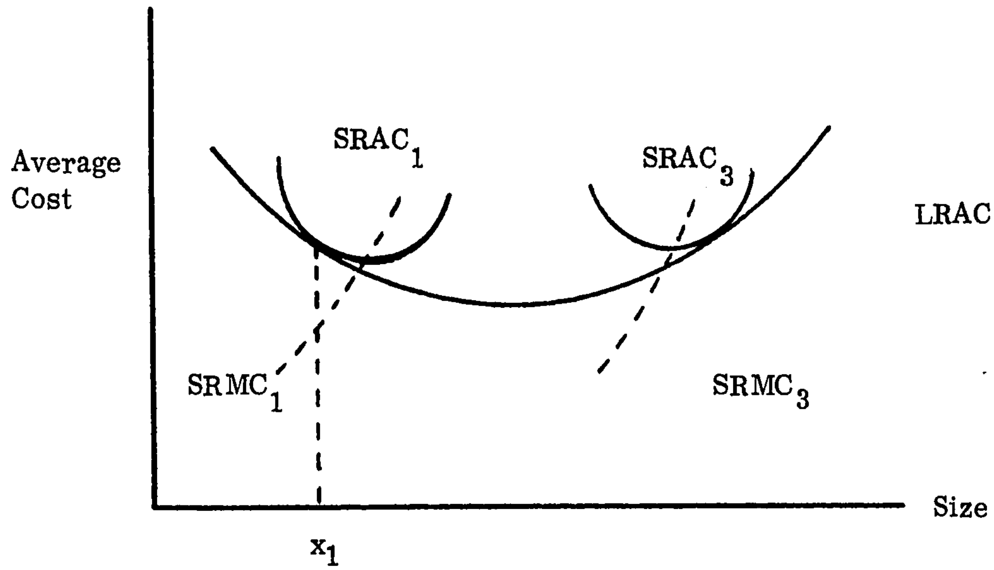
[5] Ibid., p. 61.

[6] Ibid., p. 62.

It was therefore, necessary to investigate the cost-size relationship of many hospitals, each of a different size.[7]

Figure III

Theoretical Relationship Between Average Cost and Size of the Firm



Before we proceed to the cross-sectional study, let us evaluate the argument to this point. The first criticism is that Feldstein fails to indicate clearly what definition of capacity he has in mind. On the one hand, capacity may be defined as the output at the lowest point on the short-run average cost curve. If this is the definition that he has in mind, then his analysis is questionable. Excess capacity would merely imply that the short-run average cost curve is falling, a condition which is met by plants operating at either end of the long-run average cost curve. On the other hand, if we define capacity as the tangency of the short-run and long-run average cost curves, then Feldstein's

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[7]Ibid., p. 62.

theoretical analysis has some merit. He is correct in arguing that a plant operating on the falling portion of $SRAC_3$ implies excess capacity. However, he is incorrect in arguing that a plant operating on the falling portion of $SRAC_1$ implies full capacity; excess capacity exists up to an output of x_1 and thereafter full capacity exists.

Another weakness in Feldstein's analysis is his statement that an average occupancy rate of 90 percent implies full capacity. What do hospitals mean by full capacity? Presumably they mean that all beds are being used. If this is the case, what point does this give us on the short-run average cost curve? A priori, there is no reason to suggest that it is either the minimum of the short-run average cost curve or the tangency of the short-run and long-run average cost curves. This is an empirical question which must be considered. Feldstein's avoidance of it leads one to question his results.

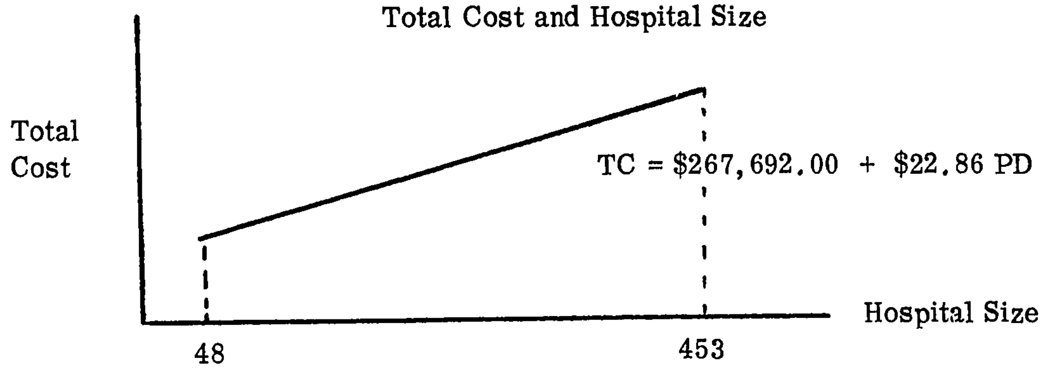
Having recognized the deficiency of inferring scale effects from the study of one hospital's short-run cost curves, Feldstein then proceeds to a cross-sectional study. Using data from sixty hospitals, he finds the long-run total cost curve to be linear with a positive constant term (Figure IV). In other words, economies of scale exist throughout the entire range of hospitals in the sample. The major criticism of the cross-sectional study is that costs are regressed on heterogeneous patient days. Although Feldstein does not consider the quality differential among various sized hospitals, he qualifies his findings in the following manner.

> ... large hospitals do have higher total costs, but as size increases the increase in total cost is constant. Since no

> allowance has been made for the number of services offered by each hospital in this sample, there is a large upward bias that results. This bias is caused by the increase in the number of services and not from increases in the size of hospitals. Therefore, if the number of services could be allowed for, one would expect the total cost in hospitals of increasing size to increase at a decreasing rate ...[8]

Figure IV

Measured Relationship Between
Total Cost and Hospital Size



In other words, Feldstein correctly admits that, because larger hospitals provide a more expensive product mix, scale effects are understated in the regression equation which he has estimated. A second criticism is that the size range from a 48 to a 453 bed hospital is very restrictive. The problem facing administrators is not whether to build a 200 or a 400 bed hospital but whether to expand or build new hospitals in the range of 1000 beds. As indicated in Table 3 (p. 25), hospitals of 500 beds and over account for approximately 32.6 percent of total hospital beds in the Province of Ontario. Accordingly, an analysis of inter-hospital costs which does not include hospitals of over 500 beds is unsatisfactory because the results would not be applicable to most hospital systems.

A question of definition arises with respect to the term "total cost."

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[8] Ibid., p. 64.

Feldstein, without giving reasons, excludes depreciation charges in the computation of per diem costs. Presumably, the exclusion is based on the argument used by administrators that, since plant facilities are gifts from governments and/or the public, they have already been paid for and consequently should not be included in the cost to the patients. Detailed arguments in regard to the inclusion of capital charges will be presented later in Chapter III. In brief, economists define the long-run total cost to include the imputed cost of capital. Whether or not the depreciation costs are charged directly to the users is immaterial in an investigation of scale effects. As will be argued later, deterioration of plant is a real cost to society and consequently a capital cost allowance must be made; otherwise, what we are really doing is estimating scale effects by regressing the short-run total cost on output.

In a later and more sophisticated study, Feldstein and Carr[9] use two dissimilar approaches to estimate the cost-size relationship in the hospital industry. In the first approach, multiple regression analysis is applied to the data from 3,147 United States voluntary short-term hospitals. The determinants of inter-hospital cost variations are postulated to be the following: hospital size, the number of services in the hospital, the number of out-patient visits, the number of student nurses, the number and types of internship and residency programs, the number of interns and residents, and affiliation or non-affiliation

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[9] W. John Carr and Paul J. Feldstein, "The Relationship of Cost to Hospital Size," Inquiry, IV (June 1967), 45-65.

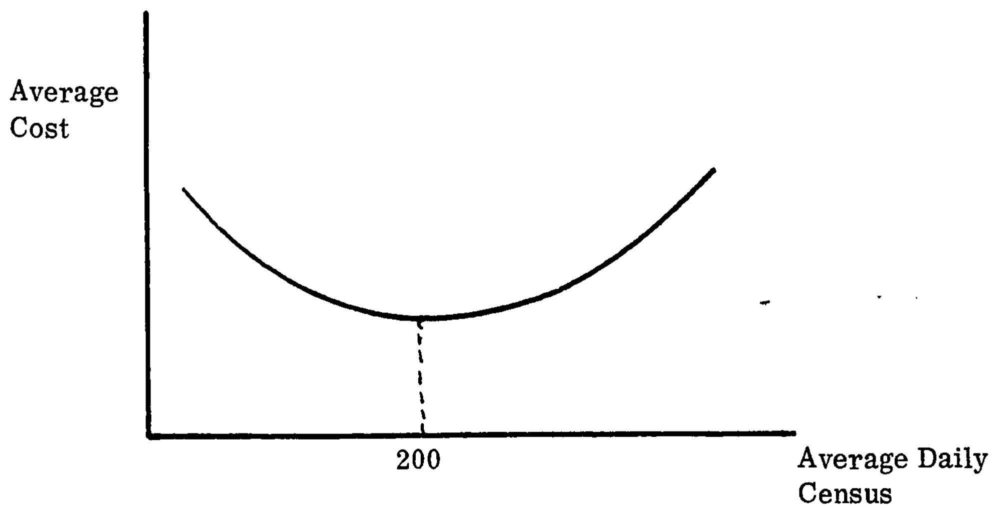
with a medical school. For the cost-size relationship, the relevant portion of the multiple regression equation is

$$AAC = \$171,085\ (PD)^{-1} + \$30.31 + \$0.0000351\ (PD)$$

where AAC is the average cost, adjusted to take account of wage differentials among hospitals, and PD is the hospital's average daily census. As indicated in the graphical illustration (Figure V), the optimum hospital size is approximately 200 beds.

Figure V

Measured Relationship Between
Average Cost and Hospital Size



The authors correctly make note of the shortcomings of the analysis. In the first place, a numerical count of services and facilities implicitly assumes that the cost of the services and facilities are approximately equal. Furthermore, the model implicitly assumes that the degree of utilization of the individual services is approximately the same among hospitals. The evidence contradicts the above assumptions; not only do larger hospitals provide more expensive services and facilities but they also make greater use of these services and facilities. Having made these observations, the authors qualify their results in the following manner: "The degree of the initial decline in cost will be underestimated and the amount of the rise in cost at large levels will be overestimated."[10] The authors then proceed to an analysis which hopefully takes into account the different types of services and different utilization rates.

In the second approach, the hospitals are divided into five service capability groups as indicated by Table 1. Using essentially the same variables as in the previous analysis, regression analysis is then applied to each group. The relevant portions of the regression equations are illustrated in Figure VI. The findings are in agreement with those of the previous analysis. Unfortunately, the authors present the multiple regression results in an unconventional form and exclude tests of significance such as the coefficient of multiple determination and analysis of variance tables. Consequently, neither the performance of the equation as a whole nor the contribution of the explanatory variables (including size) can be evaluated. The criticism made in the first approach with regard to the equal weighting of various facilities is also applicable to the latter analysis. The equal weighting procedure can be justified only if the cost of the various facilities is the same. Otherwise, the construction of an output index is required in which the various services are weighted according to their respective costs. Unfortunately, the necessary cost data is not available. Despite the above shortcomings, the analysis is important because it draws

[10] Ibid., p. 60.

attention to the effect of the various services on hospital costs.

TABLE 1

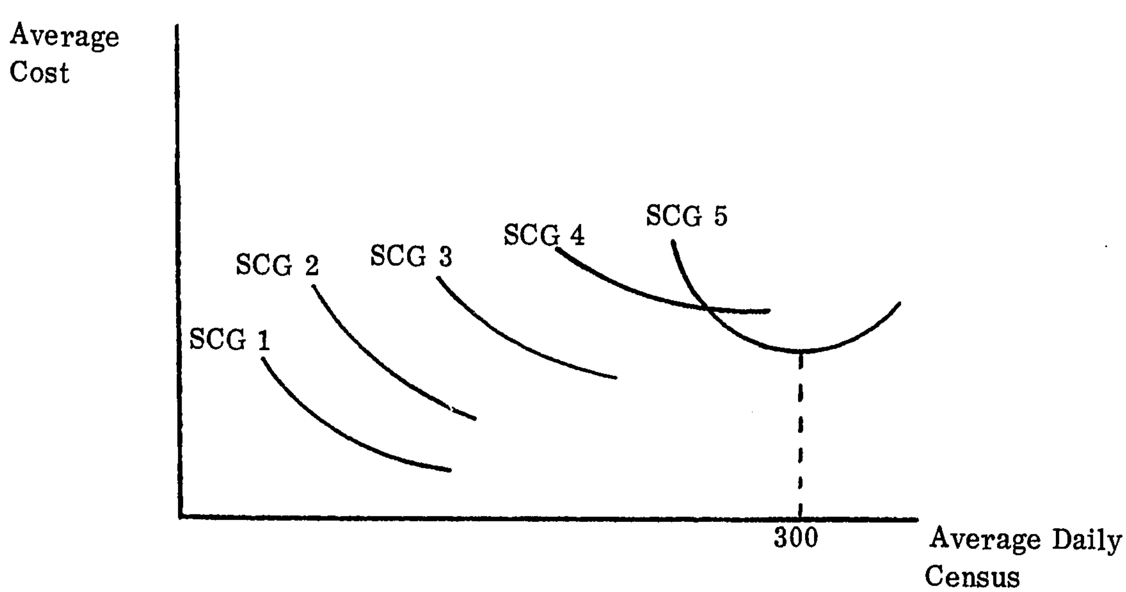
HOSPITALS BY SERVICE-CAPABILITY GROUP

Service-Capability Group	Number of Facilities, Services and Programs (S)	Number of Hospitals	Mean Average Daily Census (ADC)
SCG 1	0 through 9	680	26
SCG 2	10 through 12	693	46
SCG 3	13 through 16	729	93
SCG 4	17 through 19	490	170
SCG 5	20 through 28	555	294

Source: Carr and Feldstein, ibid., p. 61.

Figure VI

Measured Relationships Between
Average Cost and Hospital Size
According to Service Capability Groups



Using data from 5,293 United States general hospitals, Berry[11] divides hospitals into 40 groups on the basis of identical services and facilities. The sample size of each group ranges from 10 to 92 hospitals; the majority of the groups have a sample size of less than 15 hospitals. For each group he postulates a linear regression of the form $Y = a + bx$, where Y is the average cost and x is the average daily census. The correlation coefficient between average cost and the daily census is found to be significantly negative in 36 out of the 40 groups. Hence the conclusion is reached that economies of scale exist.

Berry's method of grouping hospitals with identical services is an improvement over the studies mentioned earlier. However, his hypothesis of a linear relationship between cost and size is open to criticism. Implicitly, he assumes either economies or diseconomies of scale throughout the entire range. Traditionally, the average cost curve is postulated to be U-shaped. Consequently, the correct procedure is to specify a polynomial of the third degree and then test the polynomial as to the suitable degree.

In the analysis, Berry develops an interesting argument to the effect that economies of scale are due in part to the higher occupancy rates of larger hospitals. The argument is as follows:

> Suppose two contiguous geographical areas, A and B, are considered. Let X and Y represent the average number

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[11] R. E. Berry Jr., "Competition and Efficiency in the Market for Hospital Services, the Structure of the American Hospital Industry" (unpublished Ph.D dissertation, Harvard University, 1965).

> of persons requiring hospitalization in A and B, respectively. If each area were served by a hospital, the average daily census of A's hospital would be X, the average daily census of B's hospital would be Y. The variances of the two distributions can be represented by Var(X) and Var(Y). The standard deviation in each case would be the square root of variance of the distribution, $\sqrt{Var(X)}$ and $\sqrt{Var(Y)}$.
>
> Now suppose that both areas A and B were served by a single hospital. The average daily census of that hospital would be simply X + Y ... The variance of the distribution would be Var(X) + Var(Y), ... But, the standard deviation of the distribution would be $\sqrt{Var(X) + Var(Y)}$ which is necessarily less than $\sqrt{Var(X)} + \sqrt{Var(Y)}$. Therefore the two areas could be served by a single hospital with fewer beds as by the two separate hospitals with their combined number of beds ... the relationship between hospital and occupancy rate represents a true economy of scale.[12]

Berry's analysis is correct only if the two areas are independent such that the overflow of one hospital does not have access to the other hospital. The reason for the higher occupancy rate in the larger hospital is not the size of the hospital but the greater population served by that hospital. For example, if areas A and B represented the halves of a city in which patients could choose either hospital, the total standard deviation of the two individual hospitals would be $\sqrt{Var(X + Y)}$, which in turn is the standard deviation of a single hospital serving A and B. The scale effect is due to the population and not to the size of the hospital.

Martin Feldstein, in a study of hospitals in the United Kingdom, states, without elaborating, that in estimating scale effects the correct procedure is to regress cost per case on hospital size thus allowing for "the possible influence of hospital size on duration of stay."[13] Prior to the regression

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[12]<u>Ibid</u>., pp. 122-123.

[13]Martin S. Feldstein, <u>Economic Analysis for Health Service Efficiency</u> (Amsterdam: North-Holland, 1967.), p. 59.

analysis, factor prices were examined and found to be uniform with the exception of London. An adjustment in London prices would have been required only if London's size distribution of hospitals differed from the rest of the country. However, this was not the case. In defining the hospital's operating cost, Feldstein excludes depreciation expenses. As discussed previously, the exclusion is theoretically unsound. Without making output adjustments, Feldstein then estimates a cost function and concludes that the results are meaningless because larger hospitals treat the more costly cases. Consequently, an adjustment for the various cases is required. Feldstein begins by classifying the hospital's output into 9 broad categories (such as general medicine and paediatrics). Costs for the various categories are estimated and the hospital's output is adjusted by weighting the various cases according to their respective costs. Regression analysis is then applied to estimate the following: a single equation for the entire range, individual equations for two subgroups, and individual equations for four subgroups. The results from the various equations are in general agreement that the cost function is a "slightly U-shaped curve with a minimum in the range of 250 to 350 beds."[14]

Although Feldstein's casemix adjustment reduces the degree of heterogeneity within the sample, it is not entirely satisfactory.

> The trouble arises because there remains a great deal of variation in costs per case within each of these categories. In particular, the category of "general surgery" encompasses a very broad range of procedures, from the

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[14] Ibid., p. 71.

> relatively inexpensive (such as haemorrhoidectomy) to the highly expensive (such as the removal of abdominal neoplasms), and this category accounts for 32 percent of all cases; similarly heterogeneous is the category of "general medicine", which accounts for another 17 percent.[15]

Feldstein also questions the validity of the above results; he argues that the lack of scale effects after a hospital size of 350 beds is probably due to a lower caseflow (number of cases treated per bed per year) in larger hospitals. Empirically, the flow rate is found to be negatively correlated with hospital size. An adjustment for this differential is made and the cost curves are re-estimated. Feldstein's caseflow adjustment is correct only under special circumstances. First, if the lower caseflow is due to lower occupancy rates in larger hospitals, then the adjustment is correct. However, this was not the case. Second, if the lower caseflow is entirely due to larger hospitals treating the more complicated cases, then the caseflow adjustment is warranted. However, an adjustment (namely, a casemix adjustment) has already been undertaken to take account of the more complicated cases. Consequently, a further adjustment would be incorrect because it would lead to a "double-counting" or over-weighting of the more complicated cases. In other words, the correct procedure is to make either a casemix or a caseflow adjustment but not both. Third, if the lower caseflow is in part due to diseconomies of scale, then a complete caseflow adjustment would be

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[15] R. Barlow, Review of Economic Analysis for Health Service Efficiency, by Martin S. Feldstein, in The Economic Journal, LXXVIII (December 1968), 922.

incorrect because it would overstate scale effects.

Using a similar analysis, Feldstein estimates the cost function for the individual cost categories (such as medical salaries per case and drugs per case). The empirical results that emerge indicate that the domestic staff and direct components (such as drugs and dressings) are subject to diseconomies of scale whereas nursing and medical services are optimum at a hospital size of 409 and 548 beds respectively. Despite its shortcomings, Feldstein's study is a major contribution to the literature because of its development of an output index and its estimation of scale effects in the various cost categories.

Applying sophisticated statistical techniques to the 1958-59 cost data for 72 Massachusetts hospitals, Ingbar and Taylor[16] attempt to determine the factors relevant in explaining inter-hospital cost variations. They argue that, because of the large number of possible explanatory variables, past experience, common sense, and economic theory are not adequate in specifying the relevant variables. Consequently, it is necessary to screen the possible explanatory variables. The principle component method of factor analysis[17] is used and eleven variables are identified as being important.

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[16]M. L. Ingbar and L. D. Taylor, Hospital Costs In Massachusetts: An Econometric Study (Cambridge, Massachusetts: Harvard University Press, 1968).

[17]The method of principle components was developed by H. Hotelling, "Analysis of a Complex of Statistical Variables into Principle Components," Journal of Educational Psychology, XXIV (1933), 417-41, 498-520.

Although the principle component method has been used frequently by psychologists, its use in economics has been very limited. However, in recent years, it has been suggested that the factor analysis technique be used as an alternative to least squares when there is high multicollinearity in the original variables. For example, see J. T. Scott Jr., "Factor Analysis and Regression," Econometrica, XXXIV (July 1966), 552-562.

Multiple regression analysis is then applied and the average cost is found to be an inverted U peaking in the 150 to 200 bed range. The conclusion is reached that "whatever its exact shape - the average cost curve does not fall monotonically, at least in the 30 to 330 bed range of hospital size, for which results are relevant."[18] The authors attempt to reconcile their empirical results with those of the theoretical model by arguing that diseconomies of scale in the lower range are due to the fact that as hospitals become larger they provide more services. The reasoning is questionable because the multiple regression technique when used to estimate scale effects holds all other factors which are included in the equation constant. A possible explanation as to the inverted U may be the manner in which the variables are specified. Because the explanatory variables are quantified in terms of yearly volume rather than ratios (such as laboratory units per diem), they tend to be highly correlated. As a result of this multicollinearity, the effect of the explanatory variables on total cost cannot be separately assessed.

III. Summary

This chapter has been concerned with a review of the various methods used to estimate economies of scale in the hospital industry.[19] The

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[18] Op. cit., p. 107.

[19] Some studies were not reviewed because of similarities with the above mentioned authors. For example, Kong Kyun Ro, "Determinants of Hospital Costs," Yale Economic Essays (Fall Issue, 1968), pp. 185-256.

results which are summarized in Table 2 indicate that there is no general consensus as to the optimum size: P. J. Feldstein and R. E. Berry find economies of scale throughout; the Carr-Feldstein and Martin Feldstein studies find the optimum scale to be in the 300 bed range; and the Ingbar-Taylor study suggests an inverted U peaking in the 150 to 200 bed range.

TABLE 2

SUMMARY OF SCALE ESTIMATES
FOR THE HOSPITAL INDUSTRY

Author	Results
P. J. Feldstein	Economies throughout
W. J. Carr and P. J. Feldstein	Optimum size in the 200 to 300 bed range
R. E. Berry	Economies throughout
Martin Feldstein	Optimum size in the 250 to 350 bed range
M. L. Ingbar and L. D. Taylor	Inverted U peaking in the 150 to 200 bed range

The major criticisms that emerge are twofold. First, the authors, although well aware of the conceptual problem of defining hospital output, ignore it for the most part. Second, the authors fail to include depreciation charges in their definition of long-run total costs. As will be argued later, exclusion of depreciation may bias the estimated cost curves.

CHAPTER III

ESTIMATING SCALE EFFECTS USING "HOTEL-TYPE" COSTS

I. Introduction

The major criticism of the studies discussed in Chapter II is that adjustments to take account of the quality differential were unsatisfactory because the economists responsible for these studies, although well aware of the nature of the problem, were unable to propose an adequate solution. In this chapter, a "hotel-type" services model is introduced, tested empirically, and critically evaluated. The first step in the "hotel-type" services model is to restrict the sample size to include only accredited hospitals. Although this procedure does not lead to a homogeneous industry output, it does succeed in reducing the degree of heterogeneity in the sample. The remaining quality differential that exists is due to the fact that some hospitals provide a greater volume of diagnostic and therapeutic services per diem. Consequently, to enable meaningful comparisons to be made between hospitals, these treatment services must be excluded. What then remains are the accommodation or "hotel-type" services. Proceeding on the assumption that accommodation in accredited hospitals is of similar quality, we then apply regression analysis to estimate scale effects.

II. The Model

Inclusion of Accredited Hospitals

The only body authorized in Canada to conduct an accreditation program is the Canadian Council on Hospital Accreditation.[1] The accreditation program, which is voluntary, is carried on by the Council in co-operation with hospital governing boards, administration and medical staff for the purpose of promoting high quality hospital care. When a hospital requests accreditation status, a medical staff of field representatives conducts a survey of the hospital and collects information on physical facilities, medical, nursing,and technical staff, medical procedures, and administrative organization. The "Hospital Survey Report" is then sent to the executive office where it is reviewed by the head office staff and voted upon by the Directors of the Council; a majority of votes gives the hospital accreditation status. By excluding non-accredited hospitals, one increases the degree of homogeneity in the sample. To the extent that accredited hospitals have satisfied certain pre-requisites, the quality of care in them is standardized; specifically, the quality of care is upgraded. Table 3 gives the distribution of output by relative size prior to and after the exclusion of non-accredited hospitals. The Table indicates that the majority of

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[1]The Canadian Council on Hospital Accreditation was incorporated in 1958 as a member organization of the Joint Commission on Accreditation of Hospitals. For accreditation requirements, see the Commission's official document, Standards for Hospital Accreditation (Chicago: Joint Commission on Accreditation of Hospitals, 1957).

TABLE 3

DISTRIBUTION OF OUTPUT OF HOSPITAL SERVICES
FOR THE PROVINCE OF ONTARIO
BY RELATIVE SIZE, 1965

	ALL HOSPITALS			ALL ACCREDITED HOSPITALS		
Hospital Size (rated bed capacity)	Number of Hospitals	Percent of Hospitals	Percent of Hospital Beds	Number of Hospitals	Percent of Hospitals	Percent of Hospital Beds
900 +	3	1.7	9.1	3	3.2	12.2
500 - 899	12	6.7	23.5	12	12.6	28.1
400 - 499	3	1.7	4.1	3	3.2	5.1
350 - 399	8	4.5	8.6	7	7.4	9.4
300 - 349	13	7.3	12.2	11	11.6	12.7
250 - 299	10	5.6	7.8	9	9.5	8.8
200 - 249	13	7.3	8.6	13	13.7	10.6
150 - 199	13	7.3	6.3	9	9.5	5.5
100 - 149	20	11.2	6.9	10	10.5	4.0
1 - 99	84	46.9	12.9	18	19.0	3.6
TOTAL	179	100.0	100.0	95	100.0	100.0

Calculated from: Ontario Hospital Services Commission, 1965 Annual Report (Statistical Supplement), Table 19, pp. 98-104.

hospitals of over 300 beds are accredited whereas less than one half of those hospitals under 300 beds are accredited. Fortunately, this does not present a problem as the sample of accredited hospitals is adequate, both in terms of size and distribution.

Classification of Costs

To the extent that some hospitals provide a greater volume of diagnostic and therapeutic services per diem, there remains a quality differential among accredited hospitals. Consequently, to enable one to make meaningful inter-hospital cost comparisons, the costs reflecting these services must be taken into account. To do this, we divide costs into three categories; those pertaining to the "hotel-type" or accommodation services, those pertaining to medical and nursing education, and those pertaining to treatment services. Thus we may write

$$(3.1) \quad TC = HC + TR + E$$

where TC is the total operating cost, HC the "hotel-type" cost, TR the cost of treatment, and E the cost of medical and nursing education. The exclusion of treatment and education costs requires a decomposition of total operating costs into components attributable to the above mentioned categories. To do this, a detailed analysis of the departmental costs as given by Table 4 follows.

Nursing Costs

Total nursing costs are normally divided into general and special nursing costs. General nursing expenses, accounting for 32.9 percent of total

TABLE 4

DEPARTMENTAL DISTRIBUTION OF GROSS OPERATING COSTS
ON A PER DIEM BASIS
AVERAGE OF ALL HOSPITALS
IN THE PROVINCE OF ONTARIO, 1965

Department	Per Diem Cost	Percent of Total Operating Cost
Special Nursing Services	$ 2.06	5.9
General Nursing Services [a]	11.42	32.9
Laboratory	1.92	5.5
Radiology	1.66	4.8
Other Special and Supplemental Services [b]	1.45	4.2
General Administration	3.43	9.9
Dietary	3.64	10.5
Laundry and Linen	.96	2.8
Housekeeping	1.65	4.8
Operation and Maintenance	2.11	6.1
Medical Education	.30	.9
Nursing Education	1.23	3.5
Building and Building Service Equipment (non-shareable)	.99	2.9
Depreciation on Equipment (shareable) [c]	.84	2.4
Bad Debts	.11	.3
Other [d]	.92	2.7
Total	$ 34.69	100.0

a) Breakdown of nursing services as derived from Dominion Bureau of Statistics, 1965 Annual Return of Hospitals Form HS-2, for hospitals in Ontario.

b) Excludes Special Services for which costs are non-allowable, e.g. Research, Organized Out-patient Department, and Mental Health Clinic.

c) Shareable refers to the fact that depreciation charges are recoverable from the Ontario Hospital Services Commission.

d) Consists chiefly of non-allowable costs excluding depreciation on building and building service equipment.

Calculated from: Ontario Hospital Services Commission, 1965 Annual Report (Statistical Supplement), Tables 19, 20, 21, pp. 98-119.

operating costs, constitute the largest component of costs. They include all the expenses incurred in operating the nursing units (floors, wards, or departments organized to provide direct care to in-patients), plus the cost of nursing administration. Nursing administration costs are those relating to the cost of managing the nursing department and normally include the expenses of the administrative nursing service office, the salaries of the nursing directors, and other nursing expenses not identified with either patient service departments or with nursing education.

Special nursing costs include all the expenses incurred in operating the following departments: major and minor operating rooms, auxiliary rooms such as post-operative recovery rooms, fracture rooms, cystoscopy rooms, delivery and labour rooms, the emergency unit, and the central supply room. The emergency unit includes the dressing rooms, examining rooms, and operating rooms which are primarily used for emergency services. The central supply room includes the cost of all medical, surgical, and sterile supplies issued directly to this room, even though they may be subsequently allocated to other departments.

In Chapter II, the quality of hospital care is described in terms of two dimensions; the first dimension refers to the range of services offered whereas the second refers to the quality of a particular service. To reduce the degree of heterogeneity within the sample, we examine only the "hotel-type" services. In other words, costs incidental to the treatment dimension must be excluded. Better treatment involves not only more laboratory, radiology, and drug services but also more specialized nursing services. Consequently, specialized nursing services are regarded as a treatment service and are excluded from our "hotel-type" services model.

Laboratory and Radiology

This group of costs consists of those items necessary in providing laboratory, diagnostic radiology, and radiotherapy services. Included in laboratory services are the costs of providing pathology, histology, autopsy, morgue, biochemistry, serology, blood bank, electrocardiography, bacteriology, haematology, immunology, parasitology, endocrinology, basal metabolism, and photographic services. Laboratory and radiology services being components of the treatment category are consequently excluded from the analysis even though they account for 10.3 percent of total operating costs.

Other Special and Supplemental Services

This category includes the cost of providing pharmaceutical, physiotherapy, medical record, and medical library services. Included in pharmaceutical costs are the costs of drugs provided by the pharmacy to individual in-patients and out-patients. Drugs issued to other departments by the pharmacy are subsequently charged to the respective departments.

The question now arises as to whether or not one should include the special and supplemental services in the "hotel-type" services model. One may argue that within the sample of accredited hospitals there is no reason for the per diem volume of these services to vary among hospitals. Consequently, they should be included in our "hotel-type" services model. This argument is rejected for two reasons. First, the empirical evidence refutes the supposition that the per diem volume of these services is constant among hospitals; larger hospitals do provide a greater per diem volume of special and supplemental services. Second, we will adopt the wisdom of the oft-repeated tenet, "when in doubt, err on the safe side." In other words, services not definitely attributable to "hotel-type" services are excluded from the analysis. Special and supplemental services fall into this category.

General Administration

Administration costs consist of those items necessary in the overall administration of the hospital and normally include the following sub-departments: accounting, admitting, collecting, switchboard and receiving, personnel, purchasing, chapel, employee health services, and public relations. This category of costs is included in the "hotel-type" services model.

General Services

The following departments are included under general services: dietary, laundry, linen, housekeeping, and the operation and maintenance of the physical plant. Dietary costs refer to the expenses of providing food to in-patients and include food costs as well as wages earned by dietitians, cooks, and other kitchen personnel. Included in laundry and linen costs are wages, washing and laundry supplies, and bedding and linen replacements. Included in housekeeping costs are the wages of the cleaning staff, cleaning supplies, and the cost of outside services such as window-washing and insect-extermination.

Included in the operation and maintenance of physical plant are those items necessary in the operation and maintenance of the hospital's roads, grounds, equipment, water, light, heat, and power systems.

Depreciation

Depreciation cost data are normally reported under three categories: depreciation on buildings and building service-equipment (non-shareable), depreciation on major equipment (shareable), and depreciation on major equipment (non-shareable). In the computation of per diem costs, hospital administrators exclude depreciation on building and building service-equipment. The exclusion is based on the argument that, since plant facilities are gifts from governments and/or the public, they have already been paid for and therefore should not be included in the cost to the patients. The above argument is not applicable to our study for two reasons. The first is that depreciation of plant is a real cost to society in the sense that plant facilities do not last forever; either they wear out or they become obsolete. Consequently, an allowance should be made for this deterioration and obsolescence. Whether or not it is directly charged to the users is immaterial to our study. Second, meaningful inter-hospital comparisons can be made only if plant and plant equipment depreciation is included. Otherwise, the capital intensive hospital, having higher labour productivity, would appear to be more efficient in the sense that it has a lower per diem wage cost. Consequently, capital costs must be included to offset the lower wage costs. Otherwise, exclusion of depreciation charges in the regression analysis may affect the estimates of scale effects in either one of two ways, both of which are undesirable. First, if the capital-labour ratio is positively correlated with size, exclusion of depreciation will overstate scale effects. Second, if the capital-labour ratio is random with respect to size, exclusion of depreciation will not affect the coefficient estimates but will, nevertheless, increase the deviation about the cost-output relationship.

Of the two remaining categories, depreciation on major equipment (shareable) and depreciation on major equipment (non-shareable), only the latter is excluded in the hospital's computation of per diem costs. However, in the "hotel-type" services model both categories are excluded, the argument being that better hospitals, having more sophisticated equipment, have higher equipment depreciation costs. In other words, the quality disparity among accredited hospitals exists, in part, because some hospitals have more sophisticated equipment than others. Consequently, the costs reflecting the equipment services must be excluded.

Bad Debts

Hospitals, like any other business, rarely collect all their accounts receivable; either they incur collection expenses or they write the uncollectible accounts off as bad debt expenses. Collection expenses, belonging to the general administration cost category, are included in the "hotel-type" services model. Consequently, bad debt expenses must be included to offset the collection expenses; otherwise the hospital which did not employ collection services would appear to be more efficient because of its lower general administration costs. An alternative procedure is to exclude both bad debt and collection expenses. However, in our case this is not feasible because the data are reported in such a manner that collection costs cannot be readily segregated from other general administration costs. Accordingly, we adopt the former procedure of including both the collection and bad debt expenses.

Aggregation of Costs

In identity (3.1), the total operating cost is defined as the sum of the costs incurred in providing "hotel-type" services, treatment services, and medical and nursing education. The cost components are now expanded to become:

(3.2) HC = GNS + GA + DIE + LL + HK + OM + BBSD + BD

where HC = cost of "hotel-type" services
GNS = general nursing cost
GA = general administration cost
DIE = dietary cost
LL = laundry and linen costs
HK = housekeeping cost
OM = operation and maintenance costs
BBSD = building and building service-equipment depreciation
BD = bad debt expense

(3.3) TR = SNS + LR + O + DE + OT

where TR = cost of treatment
SNS = special nursing cost
LR = laboratory and radiology costs
O = cost of special and supplemental services
DE = equipment depreciation
OT = non-allowable cost

(3.4) E = ME + NE

where E = cost of education
ME = cost of medical education
NE = cost of nursing education

The "hotel-type" services model uses a refined approximation of identity (3.2). From Table 3, it is noted that "hotel-type" costs account for approximately 70 percent of total operating costs, treatment costs for 26 percent, and education costs for 4 percent.

III. Problems of Estimation

Ideally, the observations on cost and output should be free of extraneous variables such as variations in factor prices; otherwise regressing costs on output would reflect these externalities and may, in turn, give misleading estimates of economies of scale. Consequently, it is necessary to examine the cost-output data for the existence of external factors.

Problem of Variations in Occupancy Rates and Definition of Output

Within the sample of accredited hospitals, the occupancy rate ranges from 55 to 100 percent. If occupancy rates are not correlated with size, differences in the rates will not distort the true cost-output relationship but will merely increase the deviation about the relationship. Although an adjustment is not required, it would, nevertheless, improve the goodness of the fit by reducing the standard error of estimate. On the other hand, if occupancy rates are highly correlated with size, an adjustment may be required. For example, if occupancy rates are negatively correlated with size, the output of larger hospitals would have to be systematically increased; otherwise regressing cost on actual patient days would underestimate the optimum size. Two types of output adjustments can be made. The first involves estimating the occupancy rate for various size classes and then adjusting the output of the individual hospital according to the occupancy rate of its respective size class. The alternative and more exact procedure is to adjust output according to the occupancy rate of the individual hospital. For example, the hospital's output could be defined as potential output, implicitly assuming that the cost of an empty bed and occupied bed are equivalent. However, it is generally held that the cost of an empty bed is approximately 75 percent of that of an occupied bed.[2] For this reason, hospital output will be defined as

$$(3.5) \qquad APD = PD + .75\,(VR)(HS)(365)$$

where APD is adjusted annual patient days, PD the annual number of patient days, VR the vacancy rate, and HS the hospital size measured by rated bed capacity.[3] This procedure is applicable to all situations, regardless of the relationship between occupancy rates and size. If, for example, occupancy rates are randomly distributed with respect to size, readjusting output in such a manner will reduce the standard error of estimate. On the other hand, if occupancy rates are negatively correlated with size, the output adjustment will

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[2]For example, see J. S. Deeble, "An Economic Analysis of Hospital Costs," Medical Care, III (July, September 1965), 138-146; Commission on Hospital Care, Thomas S. Gates, chairman, Hospital Care in the United States (New York: Commonwealth Fund, 1947), p. 279; and Seymour Harris, The Economics of American Medicine (New York: Macmillan, 1964), p. 199.

[3]An alternative procedure is to adjust the dependent variable by excluding the cost of maintaining empty beds. The adjustment procedure is as follows:

$$AHC = HC - .75\,(COB)(VR)(HS)(365)$$

where AHC is the adjusted "hotel-type" cost and COB is the cost of maintaining an occupied bed.

result in a more meaningful estimate of scale effects.[4]

Figure VII (p. 37) illustrates the estimated long-run average cost curves using the alternate measures of output. Given an occupancy rate which is random with respect to size and less than 100 percent, the use of actual patient days ($LRAC_{PD}$) underestimates the theoretical optimum whereas the use of adjusted patient days ($LRAC_{APD}$) and potential patient days ($LRAC_{PPD}$) gives an exact estimation of the optimum. The policy recommendation that emerges is that if demand permits, hospitals should be built according to the theoretical optimum. If hospitals are to operate at a specified level of less than 100 percent, the best we can do is to build hospitals of size x_1 and operate them at x_2. As illustrated by the diagram, the cost per diem will necessarily be higher for any other size of hospital.

Figure VIII illustrates the use of actual patient days to estimate the theoretical LRAC when occupancy rates are correlated with size; $LRAC_{PD1}$ reflects negative correlation whereas $LRAC_{PD2}$ reflects positive correlation. A readjustment of the curves would indicate that the greater the degree of negative correlation, the more unreliable $LRAC_{PD}$ becomes as an estimate of the theoretical LRAC. The converse is true for positive correlation. As indicated by the matrix of simple correlation coefficients in Table 12 (p. 63) occupancy rates are positively correlated with size. Consequently, little

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[4]A shortcoming of this adjustment procedure is its linear cognizance of capacity; it assumes that the cost of an empty bed is approximately 75 percent of an occupied bed regardless of the level of utilization at which the hospital is operating. The more exact procedure would be to examine the change in the cost of an empty bed as full capacity is approached and to readjust the hospital's output accordingly.

Figure VII

Estimated Long-Run Average Cost Curves
When Occupancy Rates are Random
With Respect to Size

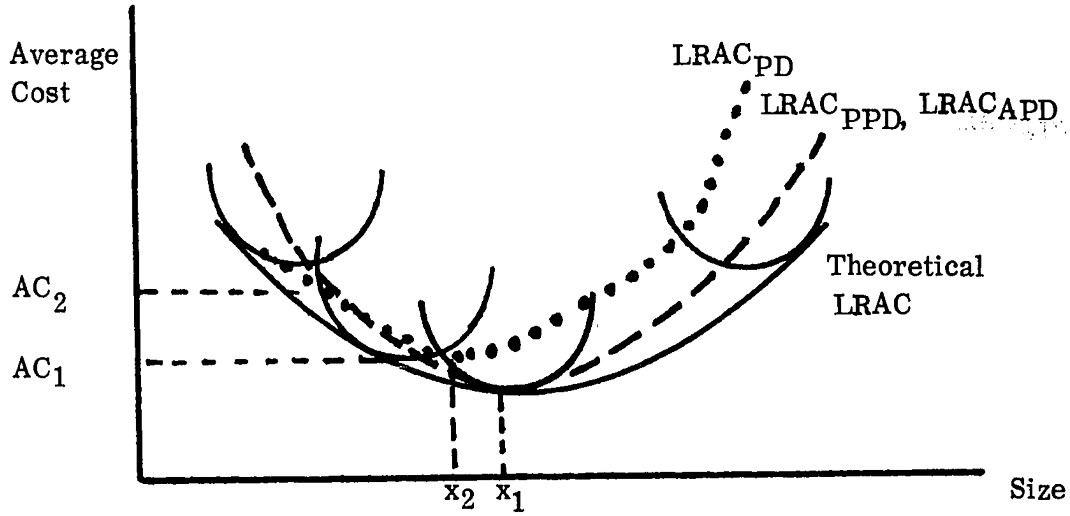
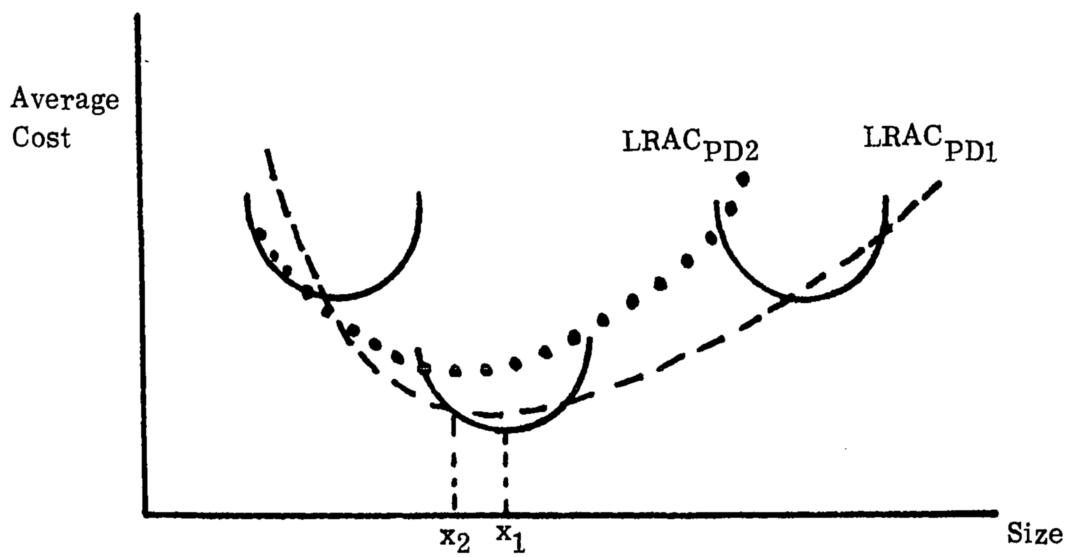


Figure VIII

Estimated Long-Run Average Cost Curves
When Occupancy Rates are Correlated
With Size



discrepancy in the estimates is expected when the alternate measures of output are used. Of the three estimates, $LRAC_{APD}$ is chosen to represent the "hotel-type" services model. The reasons are twofold. First, it gives a good representation of the theoretical LRAC and second, it is superior to $LRAC_{PPD}$ in regard to goodness of fit.

Problem of Variations in Factor Prices

The arguments made in the previous section in regard to corrections for variations in occupancy rates are applicable to factor prices. In other words, cost movements due to systematic variations in factor prices should be excluded from the cost data. Perusal of Table 5 indicates that the hospital staff, which accounts for 67 percent of total operating costs, is by far the hospital's most important input factor. Hospital employees can be categorized as skilled and unskilled; the skilled are primarily nursing personnel whereas the unskilled are dietary and cleaning personnel. A cross sectional study of hospitals admits the possibility of cost movements due to variations in the prices paid to both the skilled and unskilled personnel. Since smaller hospitals are generally found in the more remote communities, it may be argued that monetary incentives must be given to induce qualified personnel to work in these communities. On the other hand, hospitals in the smaller communities may have oligopsony power which, if combined with small town boredom, allows the hospital to pay a minimum wage to the unskilled labour force. In summary, strong arguments can be made to the effect that wages and salaries are dependent on hospital size. Therefore, it is necessary to examine whether wage rates are systematically connected with size classes.

The question of whether or not observed differences in factor prices are connected with differences in size can be answered by statistical inference; the procedure for making this inference is either "analysis of variance" or regression. Not only does the regression technique tell us whether or not the size and cost variables move together, but it also tells us how important size is.[5] For this reason, regression analysis is used to test the relationship between wage rates and size.

Empirical Testing of Differing Factor Prices

Cross sectional data was used to study the relationship between size and factor prices.[6] The following equation was assumed

$$\text{(3.6)} \quad FP = a + bX$$

where FP is the factor price, X the size of the hospital measured by rated bed capacity, and a and b the coefficients to be estimated. In the analysis, R^2 (coefficient of determination) indicates the variance of the dependent variable (factor price) which can be explained by the independent variable (hospital size). The "t" test is then used to determine the significance of each independent variable's contribution to R^2. In our case we have only one independent

[5]For advantages and disadvantages of both techniques, see Ronald Wonnacott and Thomas Wonnacott, Introduction to Economic Statistics and Econometrics (John Wiley & Sons Inc., New York, 1967), pp. 272-280.

[6]The data was obtained from a confidential Ontario Hospital Services Commission wage survey report on all hospital personnel. Unfortunately, cost data is not available for factors other than personnel.

TABLE 5

DISTRIBUTION OF OPERATING COSTS OF HOSPITALS ON A PER DIEM BASIS PROVINCE OF ONTARIO, 1965

Item	Percent of Operating Costs
Salaries and Wages	66.7
Medical and Surgical Supplies	3.2
Drugs	3.7
Administration	5.0
Food	4.5
Laundry	0
Linen	.1
Housekeeping	.1
Plant Operation	2.3
Plant Maintenance	1.0
Depreciation on Shareable Equipment	2.4
Building Depreciation	3.6
All Other	6.4
Total	100.0

Calculated from: Ontario Hospital Services Commission, 1965 Annual Report (Statistical Supplement), Table 19, pp. 98-104.

variable.

The results of the regression using equation (3.6) are summarized in Table 6. The numbers shown in parentheses are the ratios of the regression coefficients to their standard errors (t-values). In the latter two cases, the ratios indicate that the estimated coefficients of the size variable are not significant at the 1 percent level. The results for nurses' incomes present a problem. Although the t-ratio is significant, the coefficient of determination is fortunately insignificant at the 1 percent level. Consequently, it is argued that there is no discernible relationship between nurses' incomes and hospital size. This view is supported by financial representatives at the Ontario Hospital Services Commission who regard the market for hospital factors as a provincial rather than a local market.

IV. Methodology Used

A priori, we specify a polynomial of degree 3 and then test empirically as to the suitable degree. The single equation testing of the polynomial is done by a variant of the least squares method known as stepwise regression.[7] This program estimates the polynomial in a stepwise manner, inserting at each step the variable which accounts for the largest proportion of the variation in the dependent variable. The process terminates when either all the varialbes have

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[7]The program used was a modified version of Hodson Thornber, "Manual for (B34T, 8 Mar. 66) a Stepwise Regression Program," Technical Report 6603, Centre for Mathematical Studies in Business and Economics, University of Chicago.

TABLE 6

REGRESSION COEFFICIENTS BETWEEN
FACTOR PRICES AND SIZE

		NI^a	=	-157.7	+	0.4298X
t-values				(-2.757)		(3.285)
R^2	= .1030					
Sample Size	= 96					
		MI^b	=	196.1	+	0.0153X
t-values				(56.20)		(1.958)
R^2	= .05337					
Sample Size	= 79					
		LI^c	=	296.9	+	0.3260X
t-values				(1.115)		(0.3704)
R^2	= .0024					
Sample Size	= 58					

a) NI = nurses' monthly incomes
b) MI = maids' monthly incomes
c) LI = labours' monthly incomes

been tried or when the insertion of a further variable does not significantly reduce the remaining variation in the dependent variable.[8]

The equation to be tested is

$$(3.6) \qquad HC = a + bAPD + cAPD^2 + dAPD^3$$

so that the average cost curve has the form

$$(3.7) \qquad HC/APD = a/APD + b + cAPD + dAPD^2$$

where HC/APD is the cost per adjusted patient day and APD is the adjusted annual output as defined by identity (3.5). Depending on the significance and sign of the estimated coefficients, we will then be able to determine whether or not scale effects exist. For example, polynomials of the second and third degree with all but the c coefficient positive indicate U-shaped average cost curves with linear and curvilinear marginal cost curves respectively.

V. The Results

Using the above methodology, the best fitting polynomial was found to be TC_1 (see Table 7). The equation was then re-estimated using actual patient days (TC_2) and potential patient days (TC_3) as alternate measures of output.[9] As expected, the results (Table 7) are in agreement with those of TC_1. The

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[8]Variance analysis, specifically the F test, is used to determine the degree of the polynomial.

[9]The three equations can be interpreted in the following manner.

1. Equation TC_1 represents the cost per adjusted patient day (AC_{APD}) given the present average occupancy rate of 80 percent.
2. Equation TC_2 represents the cost per diem (AC_{PD}) given the present average occupancy rate of 80 percent.
3. Equation TC_3 represents the cost of maintaining a hospital bed (AC_{PPD}) given its present average occupancy rate of 80 percent.

(Continued ...)

t-ratios, which are shown in parentheses, indicate that the coefficients for the size variable are significant at the 5 percent level. Because the t-ratios for the constant terms are not significant, the equations were re-estimated by forcing the regression through the origin. The results that emerge are in general agreement with the previous ones. Of the two equations that use adjusted patient days as the explanatory variable, TC_{10} is chosen to represent the "hotel-type" services model. The R^2 is .97505 as compared to .97035 in TC_1 and the standard error of estimate is $147,069 versus $160,461.

Economic Interpretation

The empirical testing supports the traditional hypothesis of a U-shaped average cost curve. By equating marginal cost to average cost, we find the optimum sized hospital to be approximately 359 beds with an annual output of 104,828 patient days.[10] Perusal of Table 8 indicates that the average cost curve is

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The cost per diem can also be obtained from equations TC_1 and TC_3. For example, adjusted patient days are substituted into equation TC_1 to derive the AC_{APD}. The AC_{APD} is then multiplied by (1.1875) to obtain AC_{PD}. The (1.1875) factor is derived as follows:

$$
\begin{aligned}
PPD &= PD/(.80) \\
APD &= [.80 + (.75)(1-.80)]\ PPD \\
PPD &= APD/(.95) \\
PD/(.80) &= APD/(.95) \\
\therefore\ APD &= 1.1875\ PD \\
\text{Furthermore}\quad AC_{PD}PD &= AC_{APD}APD \\
\therefore\ AC_{PD} &= 1.1875\ AC_{APD}
\end{aligned}
$$

[10]To arrive at the optimum sized hospital, the annual output in adjusted patient days is divided by 365 $[.80 + (.75)(1-.80)]$.

TABLE 7

REGRESSION COEFFICIENTS
RELATING TOTAL OPERATING COST
TO SIZE VARIABLE, "HOTEL-TYPE" SERVICES MODEL

Equation Number	Regression Coefficients and (t-values) of: Constant	Size	$(Size)^2$	$(Size)^3$	Multiple Correlation Coefficient (see/$\overline{TC}$)	Optimum Size
TC_1	67,190 (1.575)	17.61 APD (24.59)		.00000000005595APD^3 (2.989)	.97035 (.11442)	244 beds
TC_2	73,470 (1.488)	19.80PD (21.13)		.00000000006598PD^3 (2.160)	.96070 (.13173)	281 beds
TC_3	97,300 (1.819)	15.63PPD (18.61)		.00000000005837PPD^3 (2.985)	.95336 (.14351)	257 beds
TG_{10}		23.20APD (19.79)	-.00007539APD^2 (-4.098)	.0000000003025APD^3 (4.594)	.97505 (.10487)	359 beds
TG_{20}		27.12PD (17.99)	-.0001130PD^2 (-4.217)	.0000000004859PD^3 (4.486)	.96724 (.12018)	398 beds
TC_{30}		22.42PPD (16.58)	-.00008729PPD^2 (-4.213)	.00000000003089PPD^3 (4.678)	.96082 (.13142)	367 beds

TABLE 8

ESTIMATED COST PER DIEM
"HOTEL-TYPE" SERVICES MODEL

Hospital Size	Cost Per Diem	Cost Per Diem as a Percent of Cost Per Diem in the Optimum Sized Hospital
50 beds	$ 26.29	120
100 beds	25.21	115
200 beds	23.51	107
300 beds	22.43	102
350 beds	21.98	100
400 beds	21.97	100
500 beds	22.16	101
600 beds	22.97	105
700 beds	24.40	111
800 beds	26.45	121
900 beds	29.17	133
1,000 beds	32.48	148

saucer-shaped in the 300 to 500 bed region with marked upward trends at both ends. Consequently, one would suspect an optimum range rather than an optimum size. Because of this suspicion, the observations were split into three subsamples for which separate linear regressions were estimated. The regression results, which are summarized in Table 9, support the above hypothesis of an optimum range. In the first two subsamples average cost decreases as size increases, whereas in the range of large hospitals average cost increases as size increases. In other words, diseconomies of scale dominate in the range of larger hospitals.

VI. Criticisms of the Model

The major criticism of the model is that it is a partial study in the sense that it examines only the "hotel-type" costs which in turn, account for approximately 70 percent of total hospital costs. Since we are analyzing "hotel-type" costs only, a logical query may be: why examine the hospital industry, why not examine hotel costs proper and make inferences regarding hospitals? Our definition of "hotel-type" costs is more comprehensive in the sense that it includes expenses not found in hotels such as general nursing services. If, for example, we found that in the hotel industry the optimum size was 300 beds, we should not infer that the 300 bed hospital was the optimum size because the inclusion of nursing costs would in all probability give a different estimate of optimum size. Furthermore, the quality differential problem is more acute in the hotel industry. Accredited Ontario hospitals do, in fact, produce a similar "hotel-type" service. This is due to three factors. First,

TABLE 9

REGRESSION RESULTS FROM SUBSAMPLES
"HOTEL-TYPE" SERVICES MODEL

Range (bed-size)		
		TC = 7668 + 24.08X
	t-values	(.2168) (21.85)
27 to 167	R^2	= .9427
	Sample size	= 31
		TC = 261,100 + 22.33X
	t-values	(1.251) (8.881)
171 to 328	R^2	= .7245
	Sample size =	= 32
		TC = 388,800 + 32.67X
	t-values	(-3.692) (28.08)
328 to 1391	R^2	= .9632
	Sample size	= 32

accreditation ensures that hospitals have satisfied certain minimum requirements in regard to equipment and medical staff. Second, construction of hospitals must be approved by the Ontario Hospital Services Commission, which in turn has published a guide to hospital construction in which various factors, such as corridor width, room size, room equipment, and colour of paint, are recommended. Third, most of the designing of hospitals in Ontario is allocated to hospital specialists of which there are a limited number. Thus hospital boards are aware of the standard of work being undertaken elsewhere. Local pride combined with the fact that outside sources pay 66 percent of the construction costs leads to imitation of previous construction. As a result, hospital rooms tend to be standardized whereas considerable quality variation can be found in hotel rooms.

Another criticism of the "hotel-type" services model is that it does not take into account the various types of patients. One may argue that hospitals which have a larger proportion of intensive care patients would have higher "hotel-type" costs due to specialized diets and more frequent changes of bedding and dressings. A similar argument can be made in regard to depreciation. Because large hospitals have more facilities, they may require more building space. Consequently depreciation charges may be overstated for large hospitals, thereby biasing the results in favour of finding diseconomies of scale. Although cost information on the above is not available, one would suppose that in relation to a per diem cost of $34.69 these differences would be of minimal importance.

VII. Conclusion

In this chapter, a "hotel-type" services model was introduced, tested empirically, and critically evaluated. The general conclusion is that the long-run average cost curve is constant over a range from 300 to 500 beds with marked upward trends at both ends. For hospitals outside of this range, costs per diem may be considerably higher.

CHAPTER IV

AN EXAMINATION OF TOTAL HOSPITAL COSTS USING MULTIPLE REGRESSION ANALYSIS

The purpose of this chapter is to examine the relative importance of the factors that affect total hospital costs and, in particular, to ascertain the impact of hospital size on costs. Section 1 advances a set of variables which have either a theoretical or logical basis for explaining inter-hospital cost variations. For some of these variables data is unavailable; consequently they will be excluded from the regression analysis. In order to disentangle the separate influence of hospital size on total cost, multiple regression analysis is used to isolate the effect of the other variables on costs. In Section II and III, the statistical results are presented, evaluated, and interpreted with the view of making policy recommendations.

I. Factors Important in Explaining Inter-Hospital Cost Variations

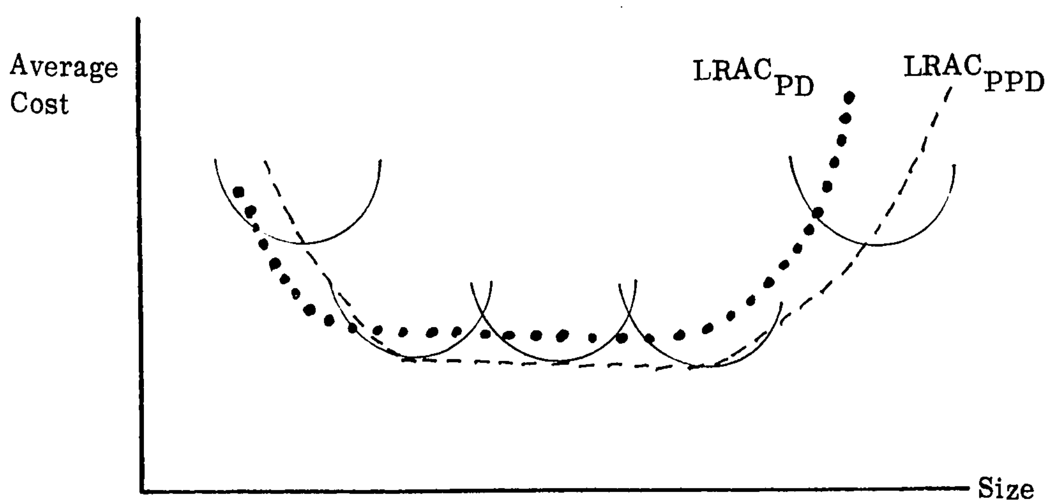
Size of Hospital

To allow for the influence of scale effects, total cost is specified in part as a function of a polynomial of the third degree in terms of the size variable. Depending on the significance and sign of the estimated coefficients, we are then able to determine not only whether scale effects exist but, in addition, their importance in explaining inter-hospital cost variations.

The question now arises as to what variable should be used to represent size. In past studies, two measures have been used, actual patient days and potential patient days. On a basis of a discussion of this problem in Chapter III, it was concluded that the more appropriate of the two measures is potential patient days. Consequently, the independent variable to represent size is specified as potential patient days. In addition, the equation will be estimated using actual patient days as the size variable. As argued previously, because of the positive collinearity between size and occupancy rates, little discrepancy in the results is expected. Furthermore, because the optimum size appears to be a range rather than a specific size, any discrepancy that occurs will be minimal. This latter argument is demonstrated in Figure IX.

Figure IX

Estimated Long-Run Average Cost Curves
When Occupancy Rates are Random
With Respect to Size



Occupancy Rates

The existence of under-capacity utilization is a common phenomenon not unique to the hospital industry. Nevertheless, in the hospital industry the problem of unused capacity becomes acute because of the high cost of maintaining an empty bed; it was noted in Chapter III that the cost of an empty bed is approximately 75 percent of an occupied bed. Therefore, hospitals with high occupancy rates will tend to have lower per diem costs. An examination of Appendix A indicates a wide range (55 to 100 percent) in the occupancy rates of Ontario hospitals. Consequently, the high cost of maintaining an empty bed combined with the wide range in capacity utilization suggests that the occupancy rate is one of the more important factors in explaining cost variations.

Type of Patient

Table 10, which draws on Feldstein's data from the United Kingdom, indicates that the cost per patient day of treating various types of patients ranges from £5.48 (general surgery) to £3.29 (traumatic and orthopaedic surgery). Accordingly, the hospital which treats a higher proportion of general surgery patients will have higher overall per diem costs. To remedy this problem, the ratios of six different patient types are included as explanatory variables. Although the inclusion of the six types reduces the degree of heterogeneity within the sample, the procedure is not totally satisfactory because the level of disaggregation, due to data limitations, is such that there remains a wide variation in the cost per case within each of the categories. In other words, the inclusion of the six patient types, although striking at the heart of the

TABLE 10

COST PER PATIENT DAY
FOR VARIOUS CASE TYPES

Case Type	Average Cost Per Day
General Medicine	£ 3.73
Paediatrics	3.36
General Surgery	5.48
Eyes, Nose, Throat	3.66
Traumatic and Orthopaedic Surgery	3.29
Other Surgery	4.16
Gynaecology	3.58
Obstetrics	3.90
Others	4.25

Calculated from: Martin S. Feldstein, op. cit., p. 174.

matter, does not go far enough in reducing the degree of product heterogeneity among hospitals.

Volume of Diagnostic and Therapeutic Services

As pointed out in the previous section, there exists a wide variation in costs per diem within each of the six categories. Presumably, a portion of this cost variation is attributable to the differential volume of diagnostic and therapeutic services required for the various cases. In general, the larger hospitals treat the more complicated cases. Consequently, one would expect a positive correlation between the volume of services and hospital size. This hypothesis is corroborated by empirical studies as well as the simple correlation coefficient in Table 12 (p. 63).[1] The volume of services per diem varies for another reason. To an extent the volume of hospital service and length of patient stay are substitutable; some hospitals may choose to give a concentrated volume of services thereby reducing the average length of stay. Accordingly, they would incur higher costs per diem and thereby appear to be inefficient although the cost per case is the same or even lower. For these reasons, the volume of diagnostic and therapeutic services per diem will be included as explanatory variables. The method of standardizing these services will be discussed later in Chapter V.

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[1]For example, see W. J. McNerney and Staff Study, Hospital and Medical Economics (Chicago: University of Michigan, 1962), II, 787.

Managerial Ability

Managerial competence is another factor to consider in explaining hospital costs. Unfortunately, there exists no suitable measure to quantify managerial ability. Alternatively, managerial ability can be represented as a dummy variable, taking on values of zero and unity to represent "good " and "bad" management respectively. The classification procedure requires familiarity with the administrators of all Ontario hospitals, information which at this time is unavailable. In addition, classifying management in the above manner is a subjective procedure, open to much criticism. Consequently, managerial ability will not be included as an explanatory variable. However, if the remaining variables are not significant in explaining cost variations, we will be compelled to remedy the above problem and include managerial ability as an explanatory variable. Contrary to the above, it may be argued that management is a scale effect and to isolate it distorts the estimated cost-size relationship. The correct procedure would then be to classify management not as "good" or "bad", but as "good" or "bad" relative to other hospitals in its size class. This procedure would increase the goodness of fit and would not distort the cost-size relationship.

Affiliation with a Nursing School

In past years, the argument was made that hospitals associated with a nursing school enjoyed free labour, thereby incurring lower per diem costs. Although this argument may have been true in the past, its validity at present is doubtful. In the regression analysis, we will exclude those costs pertaining to operating the nursing school. In addition, a dummy variable will be used to distinguish the nursing from the non-nursing school hospitals.

Factor Prices

A cross sectional study of hospitals admits the possibility of variations in factor prices. Although an examination of labour costs in Chapter III revealed that there is no discernible relationship between wages and size, this does not exclude variations in factor costs due to regional factors. However, the market for hospital factors is generally regarded as a provincial rather than a local market. This concept of a provincial market is corroborated by the extremely narrow range in wages as indicated by Appendix B.

Other Variables

Two other variables, the ratio of private rooms to total rooms and the percentage of nursing hours performed by graduate nurses, are postulated to be determinants of cost variations. The hypothesis is that hospitals with a higher ratio of private rooms and/or a higher ratio of nursing hours performed by graduate nurses would tend to have higher costs per diem.

Affiliation with a Medical School

In the computation of total operating costs we have used the accountant's cost allocation to exclude those costs which pertain to the operation of the medical school per se. Hospital administrators, however, argue that there is an additional cost over and above that which the accountants have allocated. This is due to two reasons. First, the more complicated cases throughout the Province are transferred from local hospitals to the teaching hospitals because of their more sophisticated equipment and more competent staff. Second, patients in teaching hospitals receive more expensive hospital services per diem because of the over-zealousness of interns in prescribing these services[2] and the familiarity of the teaching faculty with the new and more expensive drugs and procedures. In this study, regressions will be estimated first for the non-teaching hospitals and then for all the hospitals; in the latter case, a dummy variable will be used to distinguish the teaching from the non-teaching hospitals.

II. The Results

Table 11 summarizes the preceding discussion and introduces the notation used to denote the explanatory variables in the multiple regression analysis that follows. As indicated by the Table, seventeen variables have been postulated as possible determinants of hospital costs. The suggested signs for the case types are highly tentative in the sense that they are not based on cost information but rather on the opinions of the medical profession. The equation to be estimated is

$$\text{(4.1)} \quad TC = f\,(LAB, RAD, MED, MAT, PAED, PSYCH, CONV, CHR, OCC, NS, MS, THER, GN, PR, PPD)$$

The estimation of the equation, using the least squares method, yields the

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[2]Although not documented, financial representatives at the Ontario Hospital Services Commission have consistently found the cost of a hospital to increase upon the replacement of an experienced doctor with a recent medical graduate.

TABLE 11

LIST OF VARIABLES EMPLOYED

Symbol Used in Analysis (1)	Description of Variable (2)	Suggested Effect of and Increase of Variable on Cost per Diem (3)
LAB	laboratory units per diem	positive
RAD	radiology units per diem	positive
MED	medical patients/total patients	positive
MAT	maternity patients/total patients	not clear
PAED	paediatric patients/total patients	negative
PSYCH	psychiatric patients/total patients	not clear
CONV	convalescent patients/total patients	not clear
CHR	chronic patients/total patients	negative
OCC	occupancy rate	negative
NS	existence of a nursing school	not clear
MS	existence of a medical school	positive
THER	therapeutic units per diem	positive
GN	graduate nurses/total nurses	positive
PR	private rooms/total rooms	positive
PPD	size	negative then positive

following results:

$$
\begin{aligned}
TC_1 = & \underset{(-0.4043)}{-\,538{,}700.} \; \underset{(-0.06544)}{-\,126.2\,LAB} \; \underset{(1.259)}{+\,9{,}555.RAD} \; \underset{(-0.5665)}{-\,7{,}688.MED} \\
& \underset{(0.2461)}{+\,3{,}374.MAT} \; \underset{(-0.5005)}{-\,6{,}613.PAED} \; \underset{(-0.4847)}{-\,7{,}328.PSYCH} \\
& \underset{(1.530)}{+\,25{,}370.CONV} \; \underset{(-1.413)}{-\,18{,}850.CHR} \; \underset{(6.943)}{+\,10{,}380.OCC} \\
& \underset{(1.876)}{+\,92{,}320.NS} \; \underset{(0.5122)}{+\,1{,}031.THER} \; \underset{(2.126)}{+\,3{,}263.GN} \\
& \underset{(12.54)}{+\,32.38\,PPD} \; \underset{(-3.300)}{-\,.00009303\,PPD^2} \; \underset{(4.347)}{+\,.0000000003766\,PPD^3}
\end{aligned}
$$

R^2 = 0.98192 SEE = \$187,673.

Sample size = 163 $\overline{TC}$ = \$1,367,360.

The problem now becomes one of deciding which, if any, of the variables to exclude from the equation. Stepwise regression can be used to exclude variables which do not yield significant coefficients.[3] However, it is generally agreed that exclusion of variables should be based on either theoretical or logical considerations rather than on statistical grounds. In other words, variables should not be excluded from the analysis because of their non-significant coefficients. The equation was then re-estimated by excluding variables which have coefficient signs contrary to either theoretical or logical expectations.[4] The results are as follows:

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[3]For criticisms of stepwise regression, see T. M. Brown, Canadian Economic Growth (Ottawa: Queen's Printer, 1965), pp. 256-257.

[4]In addition, the following modifications were made.

1. Using the above methodology, the cost-size relationship was estimated

(Continued ...)

$$TC_2 = \underset{(1.391)}{9,249 \cdot RAD} - \underset{(-7.383)}{13,110 \cdot MED} - \underset{(-0.6829)}{2,042 \cdot MAT} - \underset{(-4.896)}{11,840 \cdot PAED}$$

$$- \underset{(-1.445)}{12,330 \cdot PSYCH} + \underset{(2.201)}{19,780 \cdot CONV} - \underset{(-10.09)}{24,140 \cdot CHR} + \underset{(7.150)}{10,360 \cdot OCC}$$

$$+ \underset{(1.877)}{91,720 NS} + \underset{(0.5258)}{1,051\ THER} + \underset{(2.175)}{3,309 \cdot GN}$$

$$+ \underset{(13.43)}{32.41\ PPD} - \underset{(-3.416)}{.00009370\ PPD^2} + \underset{(4.455)}{.00000000003789\ PPD^3}$$

$R^2 = 0.98135$ SEE = \$188,693.

Sample size = 163 $\overline{TC}$ = \$1,367,360.

The total cost function was then re-estimated by expanding the sample size to include teaching hospitals. A dummy variable was used to distinguish the teaching from the non-teaching hospitals. Using the above methodology, the following results were obtained:

$$TC_3 = \underset{(3.584)}{8,043 \cdot LAB} - \underset{(-0.2452)}{618.1\ MED} + \underset{(0.9453)}{3,989 \cdot MAT}$$

$$- \underset{(-0.3138)}{1,040 \cdot PAED} - \underset{(-0.5376)}{5,721 \cdot PSYCH} - \underset{(-1.634)}{19,310 \cdot CONV}$$

---

using actual patient days as the size variable. The results are in close agreement with those of TC_2 .

2. One may argue that the size variable swamps out the effect of the other variables when total cost is the functional form to be estimated. Consequently, the average cost curve was estimated. The results are in general agreement with those of TC_2; as expected, the R_2 is substantially lower; however, the coefficient of variation is approximately the same.

3. An inspection of column (3), Table 11, indicates that the expected effect on the cost per diem is uncertain in three cases. These variables were omitted from the regression analysis. The results are in agreement with those of TC_2.

$$- 14,250\,CHR + 2,852\,OCC + 45,320\,NS$$
$$(-4.172) \quad (1.334) \quad (0.6633)$$

$$+ 613,700\,MS + 2,038\,GN + 30.58\,PPD$$
$$(4.792) \quad (0.9411) \quad (12.86)$$

$$- .000004536\,PPD^2 + .00000000004512\,PPD^3$$
$$(0.2901) \quad (1.665)$$

$R^2 = .98976$ $\quad$ $SEE = \$\ 276,663.$

Sample size = 179 $\quad$ $\overline{TC_3} = \$1,989,370.$

The results differ considerably with respect to those of equation TC_2. A possible explanation may be the high collinearity between the medical school variable and the other explanatory variables. Multicollinearity results in an arbitrary allocation of the explained variance between the collinear variables and consequently it becomes difficult to disentangle their separate contributions to the explained variance.[5] Our approach to the multicollinearity problem is to examine the simple correlation coefficients (Table 12) and to exclude variables which are highly correlated with both the medical school and the size variable.[6] The laboratory, psychiatric, and nursing school variables are therefore excluded and the following results are obtained:

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[5]For a detailed discussion on the multicollinearity problem, see D. E. Farrar and R. R. Glauber, "Multicollinearity in Regression Analysis: The Problem Revisited," Review of Economics and Statistics, XLIX (February, 1967), 92-107.

[6]A second and more sophisticated method is that of artificial orthogonalization. For example, see M. G. Kendall, A Course in Multivariate Analysis (New York: Hafner Pub. Co., 1957), pp. 70-75. Alternatively, the problem of multicollinearity can be resolved by generating additional information in regard to the relationship between the collinear variables. For example, see J. Johnston, Econometric Methods (McGraw-Hill Book Company, 1963), p. 207.

TABLE 12

COEFFICIENTS OF SIMPLE CORRELATION AMONG ALL THE VARIABLES

	LAB	RAD	MED	MAT	PAED	PSYCH	CONV	CHR	OCC	NS	MS	THER	GN	PR	PPD
LAB	1.000														
RAD	-.513	1.000													
MED	-.096	-.031	1.000												
MAT	.172	-.131	-.220	1.000											
PAED	-.228	.102	-.372	-.166	1.000										
PSYCH	.328	.095	-.120	.026	-.100	1.000									
CONV	.233	.001	-.261	-.072	-.182	-.036	1.000								
CHR	.045	.021	-.621	-.264	-.186	-.053	.202	1.000							
OCC	.237	.066	-.106	-.034	-.018	-.079	.010	.138	1.000						
NS	.538	.297	-.152	-.036	-.076	.399	.070	.135	.201	1.000					
MS	.546	.231	.099	.066	-.223	.442	.102	-.114	.121	.380	1.000				
THER	.279	.161	-.038	-.022	-.081	.318	.214	-.006	.064	.268	.354	1.000			
GN	.058	.104	.222	.110	-.279	.028	-.080	-.089	-.304	.024	.040	-.064	1.000		
PR	.352	.126	.190	-.026	-.282	.173	.081	-.040	-.068	.309	.358	.196	.110	1.000	
PPD	.694	.320	-.047	.015	-.216	.439	.154	.063	.165	.636	.712	.447	-.004	3.44	1.000
TC	.520	.225	.082	-.013	-.200	.296	.089	-.025	.150	.445	.609	.394	-.040	.320	.913

$$TC_4 = \underset{(-0.1674)}{-429.6\ MED} + \underset{(1.460)}{6{,}208.\ MAT} - \underset{(-0.4165)}{1{,}420.\ PAED}$$

$$\underset{(-0.7592)}{-8{,}877.\ CONV} - \underset{(-4.284)}{14{,}840.\ CHR.} + \underset{(1.144)}{2{,}504.\ OCC}$$

$$\underset{(6.062)}{+739{,}300.\ MS} + \underset{(1.037)}{2{,}299.\ GN} + \underset{(20.76)}{35.68\ PPD}$$

$$- \underset{(-1.773)}{.00002395\ PPD^2} + \underset{(3.669)}{.00000000009031\ PPD^3}$$

$R^2 = 0.98889$ SEE = \$ 285,473.

Sample Size = 179 $\overline{TC}$ \$1,989,370.

The results compare favourably with those of equation TC_2. With the exception of the maternity and convalescent variables, which are now non-significant, the variables have signs corresponding to equation TC_2.

III. Economic Interpretation

The Effect of Size

For the cost-size relationship, the relevant portions of the multiple regression equations are:

$$TC_2 = 32.41\ PPD - .0000937\ PPD^2 + .0000000003789\ PPD^3$$
(non-teaching hospitals)

$$TC_4 = 35.68PPD - .00002395\ PPD^2 + .00000000009301\ PPD^3$$
(all hospitals)

Equating marginal cost to average cost, we find the optimum sized hospital to be 339 beds in the sample of non-teaching hospitals and 348 beds in the sample of all Ontario hospitals. Table 13 indicates that the estimated average

TABLE 13

ESTIMATED COST PER DIEM

Hospital Size	Cost Per Diem			Cost Per Diem as a Percent of Cost Per Diem in the Optimum Sized Hospital		
	"Hotel-Type" Services Model	All Non-Teaching Hospitals	All Hospitals	"Hotel-Type" Services Model	All-Non Teaching Hospitals	All Hospitals
50 beds	$ 26.29	$ 38.53	$ 35.27	120	116	103
100 beds	25.21	36.87	34.92	115	111	102
200 beds	23.51	34.49	34.41	107	104	101
300 beds	22.43	33.37	34.14	102	100	100
400 beds	21.97	33.50	34.11	100	101	100
500 beds	22.16	34.40	34.24	101	103	100
600 beds	22.97	37.58	34.76	105	113	102
700 beds	24.40	41.50	35.46	111	125	104
800 beds	26.45	46.70	36.39	121	140	107
900 beds	29.17	53.15	37.56	133	160	110
1000 beds	32.48	60.85	38.97	148	183	114

cost curves are elongated U-curves, that is, saucer shaped in the 300 to 500 bed range with marked upward trends at both ends. As indicated by Table 13, these results are in close agreement with those of the "hotel-type" services model developed in Chapter III. It should be noted that, due to the specification of the size variable, the cost estimates for hospitals other than the optimum are biased upward, the bias being more severe in the range of larger hospitals (see Figures VII and VIII, p. 37).

Capacity Utilization

As postulated in the previous section, the relationship between the occupancy rate and cost per diem turns out to be negative. The coefficient of the occupancy rate indicates that, for every one percent increase in the occupancy rate, total operating cost increases by $10,360; alternatively the overall cost per diem decreases by $.07.[7]

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[7]This result is obtained in the following manner. For the average hospital in Ontario,

TC = $1,367,360
PD = 43,747
∴ AC = $31.25

Suppose the occupancy rate increases by one percent,

∴ TC = $1,367,360 + $10,360 = $1,377,760
PD = 43,747 (1.01) = 44,184
∴ AC = $31.18

In other words, for a one percent increase in the occupancy rate, the cost per diem decreases by $.07.

Although this negative relationship is in contrast to those of John H. Hayes, op. cit., p. 89 and Charles G. Skinner, "Hospitals and Allied Institutions: Facilities, Programs, and Costs," Hospital and Medical Economics, Vol. 2, p. 790, it corresponds to that of Kong Kyun Ro, op. cit., p. 233.

(Continued ...)

Effect of Casemix

Of the six patient types, five enter the regression at significant levels. Although these results are not important with regard to policy recommendations, they are, nevertheless, important for prediction purposes. For example, the results from equation TC_2 are interpreted as follows: a one percent increase in the proportion of chronic patients decreases overall costs per diem by \$.55 whereas a one percent increase in the proportion of convalescent patients increases costs by \$.45.

Affiliation with a Nursing School

Equation TC_2 indicates that affiliation with a nursing school involves an additional cost of \$91,726 per annum or \$.79 per diem over and above that which the accountants have allocated to the school.

Existence of a Medical School

Equation TC_3 indicates that the existence of a medical school involves an additional cost of \$739,300 per annum or \$3.48 per diem. This result corroborates our hypothesis that affiliation with a medical school results in

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The discrepancy can be explained by the fact that both the Commission and Skinner used simple cross tabulations (coefficient of simple correlation) whereas our study examines the partial correlation coefficient. The partial coefficient is the relevant one since it describes the extent of the cost-occupancy relationship when the effect of other specified variables on both the occupancy rate and cost have been eliminated.

costs over and above those which the accountants have allocated to the operation of the medical school.

V. Summary

The objective of this chapter has been to determine the importance of various factors in explaining inter-hospital cost variations. In general, the results tend to support our a priori expectations. The results are now summarized.

1. The most important finding in this study is that with an increase in size, average cost initially decreases, reaches a minimum in the 300 to 500 bed range, and thereafter increases.

2. A one percent increase in the occupancy rate reduces the overall cost per diem by $.07.

3. The casemix is significant in explaining inter-hospital cost variations.

4. Affiliation with a nursing school results in an additional cost per diem of $.79 whereas affiliation with a medical school results in an additional cost of $3.48.

CHAPTER V

ECONOMIES OF SCALE IN VARIOUS DEPARTMENTS

Once the results of the previous section are accepted, other questions are immediately raised. In the final analysis, they revolve around the following question: If there are economies of scale, what are they due to? To answer this question, it is necessary to investigate scale effects in various departments. If optimum sized hospitals are not feasible and if departmental consolidations are, the estimated cost functions will then enable us to determine the extent to which the consolidations should take place. The departments to be considered are those which have been previously discussed in Chapter III. They are: general nursing services, dietary services, laundry services, linen services, housekeeping, building and service equipment, administration, operation of plant, maintenance of plant and the laboratory.

I. Problems of Estimation

Input Substitution

The first major problem involved in an analysis of departmental scale effects is that of input substitution. As pointed out by Martin Feldstein,

such an analysis is unbiased only if there is no tendency to

> substitute one type of input for another as hospital size increases .... it should be emphasized that the existence of possible or actual substitution as such does not preclude valid estimation of individual cost curves. Only the association of scale and input substitution would bias the results. The existence of substitution as such would increase the variance of the estimated cost curve coefficients.[1]

In other words, input substitution becomes a problem only if an increase in size is accompanied by a systematic substitution of one input for another. For example, to the extent that a hospital is capital intensive, it will incur higher depreciation costs and lower operation and maintenance costs. If, in addition, size and capital intensity are positively correlated, scale effects are then overstated in the operation and maintenance departments and understated in regard to capital charges. Since new hospitals are on average more capital intensive, the relevant question then becomes: Is there an association between newness and hospital size? In the Province of Ontario, hospitals of all sizes are being constructed. Consequently, it is assumed that input substitution, although increasing the standard error of estimate, does not present a problem in the sense that it distorts the cost-size relationship. Furthermore, because we are dealing with scale effects at the departmental level, the extent of aggregation is such that input substitution does not bias the results because the substitution is within departments rather than inter-departmental.

Product Heterogeneity

The most troublesome problem encountered in measuring scale

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[1] Martin Feldstein, op.cit., pp. 81-83.

effects is that of product heterogeneity. To reduce the degree of heterogeneity, the sample will include only the accredited non-teaching hospitals. No further adjustments will be made to allow for quality differentials among departments. Implicit in this, is the assumption that the quality of departmental services is uniform throughout the sample of accredited hospitals, or, at least, that there is no association between size and quality of these services.[2] For example, the quality of dietary services is assumed to be independent of size; bad food is not unique to any size class; it is common to both small and large hospitals.

Measure of Size

The third problem encountered in estimating departmental scale effects is choosing a variable to represent size. On the basis of a discussion of this problem in Chapter IV, it was decided that the most appropriate measure of output is potential patient days. The regressions will then be re-estimated using actual patient days as the independent variable

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[2]Comparing departmental services of hospitals without making allowances for quality differentials is supported by Nuffield Provincial Hospitals Trust, Casualty Services and Their Setting, A Study in Medical Care, (London: Oxford University Press), which stated:

> it is believed that inter-hospital comparisons of the cost of medical departments can be made only between the same types of hospital, but that comparisons between most service departments can be made between almost any type of hospital other than those for mental and mentally deficient patients. (p. 43)

Our procedure is more restrictive than the above in the sense that it compares departments of general hospitals only.

representing size. A discrepancy may occur if occupancy rates are associated with size. However, it was pointed out previously that in the case of Ontario hospitals occupancy rates are not highly correlated with hospital size.

In the case of the laboratory department, the use of patient days as a measure of output is not suitable. Because patients in the larger hospitals generally receive a greater per diem volume of laboratory services, regressing laboratory costs on patient days would understate scale effects. The correct procedure, therefore, is to regress laboratory costs on laboratory units. Fortunately, the Dominion Bureau of Statistics has developed a method of weighting into units the output of the laboratory department.[3]

> The unit represents 10 minutes of time, 7 minutes of which are allotted to technical functions and the remaining 3 minutes to stenographic services, glass washing and other non-technical services performed in the laboratory. Included in the number of units of value are some procedures that are performed mostly outside the laboratory, such as basal metabolic rates, electrocardiographs and electroencephalographs. Excluded from the count of units are all interpretive, clinical, diagnostic, consultative, teaching and research functions.[4]

An analogous problem of choosing a variable to represent output arises in the radiology department. The volume of diagnostic radiology is

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[3]Dominion Bureau of Statistics, Schedule of Unit Values for Clinical Laboratory Procedures (1960 ed.; Ottawa: The Queen's Printer, 1960).

[4]Ontario Hospital Services Commission, 1965 Annual Report (Statistical Supplement), p. XIV.

reported under two categories, radiological examinations and films taken. Unfortunately, there is no suitable method of weighting these services. Consequently, any attempt to regress cost on a non-standardized output becomes meaningless.

II. The Results

The methodology described in Chapter III was used to estimate scale effects at the department level. Table 14 presents the regression analysis for each of the departments. The multiple correlation coefficient and the coefficient of variation (see/$\bar{Y}$) indicate that the results are extremely good. The t-ratios indicate that the coefficients for the size variables are significant at the 1 percent level in all cases. In some cases, the t-values for the constant terms are insignificant. When this occurred the equations were re-estimated by forcing the regression through the origin; the results, although not presented in this paper, are in general agreement with those of Table 14. Table 15 presents the regression results using actual patient days as the independent variable. As expected, the results are in close agreement with those of Table 14.

The results for laboratory units must be interpreted with caution. Although there are scale effects in providing laboratory units, this does not necessarily mean that larger hospitals enjoy scale effects in the laboratory department. When patients are admitted to larger hospitals, they are administered a battery of laboratory tests. Given the negligible marginal cost of a laboratory unit, the average cost per laboratory unit will necessarily be

TABLE 14

DEPARTMENTAL ESTIMATES OF SCALE EFFECTS
USING POTENTIAL PATIENT DAYS AS THE SIZE VARIABLE

Department (sample size)	Regression Coefficients and (t-values) of: Constant	Size	$(Size)^2$	$(Size)^3$	Multiple Correlation Coefficient (see/ $\bar{Y}$)	Optimum Size
General Nursing Services (79)	-61,760 (-1.380)	11.44 (6.621)	-.00003997 (-2.231)	.0000000001100 (2.171)	.93815 (.16116)	498 beds
Dietary Services (79)	-28,940 (-1.995)	4.406 (7.847)	-.00001994 (-3.426)	.00000000007095 (4.222)	.95962 (.14259)	385 beds
Laundry Services (79)	-5,646 (-1.335)	.9126 (5.575)	-.000004799 (-2.829)	.00000000001269 (2.591)	.84712 (.24082)	518 beds
Linen Services (79)	-8,001 (-2.951)	.6042 (5.761)	-.000004047 (-3.723)	.00000000001109 (3.533)	.77148 (.34938)	500 beds
Housekeep-ing (79)	-17,240 (-1.640)	1.982 (4.872)	-.00001211 (-2.871)	.00000000005288 (4.344)	.92278 (.24594)	314 beds

TABLE 14 -- Continued

Department (sample size)	Regression Coefficients and (t-values) of: Constant	Size	$(Size)^2$	$(Size)^3$	Multiple Correlation Coefficient ($see/\bar{Y}$)	Optimum Size
Building and Service Equipment (79)	-15,150 (-1.280)	1.752 (3.824)	-.00001345 (-2.833)	.00000000005418 (3.952)	.83129 (.38185)	340 Beds
Administration (79)	-31.210 (-1.740)	4.553 (6.559)	-.00002393 (-3.326)	.00000000006957 (3.349)	.90329 (.20012)	471 Beds
Operation of Plant (79)	-3,860 (-.6318)	1.731 (7.320)	-.00001112 (-4.538)	.00000000003366 (4.757)	.89537 (.18215)	452 Beds
Maintenance of Plant (79)	-14,600 (-2.038)	1.541 (5.559)	-.00001303 (-4.536)	.00000000004778 (5.761)	.85933 (.32418)	374 Beds

TABLE 15

DEPARTMENTAL ESTIMATES OF SCALE EFFECTS
USING ACTUAL PATIENT DAYS AS THE SIZE VARIABLE

Department (sample size)	Regression Coefficients and (t-values) of: Constant	Size	$(Size)^2$	$(Size)^3$	Multiple Correlation Coeffcient (see/ $\overline{Y}$)	Optimum Size
General Nursing Services (79)	-66,980 (-1.735)	13.85 (7.646)	-.00005377 (-2.341)	.0000000001647 (2.050)	.95304 (.14043)	560 beds
Dietary Services (79)	-31,660 (-2.462)	5.434 (9.004)	-.00002892 (-3.780)	.0000000001186 (4.432)	.96778 (.12736)	418 beds
Laundry Services (79)	-5,691 (-1.434)	1.091 (5.857)	-.000006635 (-2.809)	.00000000002052 (2.483)	.86313 (.22785)	554 beds
Linen Services (79)	-8,401 (-3.014)	.7670 (5.682)	-.000006403 (3.861)	.00000000002100 (3.620)	.75432 (.36224)	522 beds
Housekeep-ing (79)	-2,050 (-2.228)	2.574 (5.959)	-.00001938 (-3.539)	.00000000009630 (5.027)	.93987 (.21704)	345 beds
Building and Ser-vice Equipment (79)	-17,980 (-1.444)	2.302 (3.939)	-.00002152 (-2.906)	.00000000009846 (3.799)	.81037 (.40483)	374 beds

TABLE 15 -- Continued

Department (sample size)	Regression Coefficients and (t-values) of: Constant	Size	$(Size)^2$	$(Size)^3$	Multiple Correlation Coefficient (see/ $\overline{Y}$)	Optimum Size
Administration (79)	-34,370 (-1.975)	5.704 (6.981)	-.00003691 (-3.565)	.0000000001266 (3.495)	.90750 (.19573)	500 beds
Operation of Plant (79)	-5,576 (-.8449)	2.213 (7.144)	-.00001758 (-4.476)	.00000000006221 (4.528)	.87596 (.19834)	483 beds
Maintenance of Plant (79)	-14,610 (-2.039)	1.837 (5.463)	-.00001817 (-4.264)	.00000000007893 (5.294)	.85703 (.32681)	394 beds
Laboratory* (179)	43.90 (7.601)	3.524 (19.68)			.6862 (.27098)	Economies throughout

* Laboratory units are specified as the independent variable.

lower although the laboratory cost per diem may be higher. The policy question then arises as to what the suitable procedure is. Should hospitals administer a battery of tests or should they administer only the relevant ones? If the latter, how do you determine which ones are relevant?

The use of patient days to measure the output of the laundry department is questionable. Because the larger hospitals treat the more complicated cases, they would require a more frequent change of linen, towels, etc., and thereby incur a greater volume of laundry per diem. Therefore, the appropriate measure and one which is not available at this time is pounds of laundry per diem. However, given the fact that linen is changed daily in all hospitals, one would suppose that the additional laundry resulting from the more complicated cases would be of minimal importance. Consequently, the use of patient days as a proxy for laundry output, although perhaps understating scale effects, does not severely distort the cost-size relationship.

III. Conclusion

In summary, the regression results are consistent with our hypothesis of a traditional U-shaped average cost curve. Furthermore, they tend to support the conclusion reached in both Chapters III and IV that the optimum sized hospital is in the 300 to 500 bed size range.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this dissertation has been to examine the relationship between hospital cost and size in order to ascertain the magnitude and extent of scale effects in the hospital industry. In this chapter, the results from the preceeding analysis are summarized and implications for future research are suggested.

In Chapter II, the theoretical framework of economies of scale was discussed, and the existing literature on scale effects in the hospital industry was critically evaluated. The two important defects we found were the lack of adjustment for product heterogeneity and the failure to include depreciation charges in the definition of long-run costs.

In Chapter III, a "hotel-type" services model was developed and tested empirically using 1965 cost data for 95 accredited hospitals in the Province of Ontario. The results indicated an elongated U-shaped average cost curve, that is, saucer-shaped in the 300 to 500 bed range with marked upward trends at both ends.

In Chapter IV, multiple regression analysis was used to examine the relative importance of fifteen possible determinants of hospital costs. The results are summarized as follows: (a) the optimum sized hospital is in the 300 to 500 bed range, (b) affiliation with a medical school and/or a nursing school results in an additional cost over and above that which the accountants have allocated, (c) an increase in the occupancy rate reduces the overall cost per diem, and (d) the casemix is significant in explaining inter-hospital cost variations.

In Chapter V, scale effects at the departmental level were estimated. The results lend support to the conclusions reached in Chapters III and IV that the optimum sized hospital is in the 300 to 500 bed range.

In the light of the above research, the policy implication that emerges is to build hospitals in the 300 to 500 bed range. If this is not feasible and if departmental consolidations are, the next best solution is to consolidate departments according to their respective optima. These recommendations are subject to certain qualifications. First, they are from the hospital administrator's point of view in the sense that they consider only the direct cost of hospital care and do not consider cost factors external to the hospital such as

> the use of patient's time in transit to hospital, the risk due to distance to be travelled in emergencies, the provision of in-patient care for persons who would have been seen as out-patients if they lived closer to hospital, and the reduction in use of hospital services by persons living at a distance.[1]

As a matter of public policy, both the direct and external costs of hospital care should be considered. Second, since the study is based on 1965 data,

[1]Martin Feldstein, op. cit., p. 56.

the results may not be valid, because of technilogical changes, to present or future hospitals. However, it is generally held that hospitals are subject to slow technological change. Third, the results are applicable to general hospitals in Ontario only. If, elsewhere, the concept of a general hospital is one which includes psychiatric or any other specialized wings, then the optimum range of hospital size may differ. Fourth, the recommendation in regard to departmental consolidations does not take into account the costs of consolidation. For example, in all probability it would not be advantageous to consolidate the laundry departments of two hospitals located 300 miles from one another.

A fruitful area for future research would be the development of an output index for the hospital industry. The development of such an index would require the quantifying of certain services. As mentioned previously, there are two dimensions to hospital output; the first is the range of services offered by the hospital and the second is the quality of these services. Given the appropriate data, the first dimension can be readily quantified; it requires the weighting of various illnesses by their respective costs.[2] The second dimension is more difficult to quantify. Measurement of the quality of a particular service requires an examination of the output. However, such a procedure would be extremely difficult in the case of medical services since it would require a medical audit of all ex-patients. The alternative to measuring the quality of output of a particular service is to measure the ingredients that are commonly thought to make for good hospital care. This would involve the construction of

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[2]For work in this area see Martin Feldstein, op. cit., pp. 12-15, 25-29.

an input rather than an output index.[3]

In summary, the most troublesome problem encountered in a study of scale effects in the hospital industry is the definition and measurement of output. This problem has been dealt with in our study in two ways. First, a "hotel-type" services model was developed whereby services which differentiate one hospital from another are excluded from the regression analysis; second, multiple regression analysis was used to isolate the quality variables in order to disentangle the separate influence of hospital size on total hospital costs. But it remains clear that the development of an output index, such as mentioned above, would not only facilitate estimation of scale effects but would also be important in other areas such as budgetary control and measurement of changes in productivity.

[3]A similar problem exists in education. For work in this field, see D. Dawson, "Economies of Scale in Secondary School Education in Ontario" (a study to be submitted as a Ph.D. dissertation, University of Western Ontario, 1969), and Werner Z. Hirsch, "Determinants of Public Expenditures," National Tax Journal, (March, 1960), pp. 29-40.

APPENDIX A

STATISTICAL DATA FOR GENERAL HOSPITALS IN THE PROVINCE OF ONTARIO, 1965

			Patient Type as Percent of Total Patients								
Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rate	Therapeutic Units Per Diem	Hours of Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
1	82	12	92	8					84	8	42	23
2	58	11	80		14	6			82		48	5
3	60	7	56	14			13	17	79	66	46	11
4	47	9	81	8	8	3			90	28	56	12
5	37	8	72	7	15	6			88	55	47	5
6	43	11	88	8		4			86	5	53	11
7	80	11	87	8	1	4			87	17	55	11
8	52	9	72	14	9	5			92		55	7
9	49	11	71	8	15	6			88	10	58	10
10	38	8	78	15	7				97	1	58	
11	64	15	77	6	[illegible]	7			86	35	54	13
12	44	9	71	10	11	8			83	6	56	13
13	75	13	75	20	5				83		61	11
14	53	16	81	7	11				74		59	20
15	39	6	79	11		10			91		66	18

APPENDIX A -- Continued

Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Patient Type as Percent of Total Patients: Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rate	Therapeutic Units Per Diem	Hours of Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
16	75	6	67	24	1	9			84		61	13
17	54	10	73	13	14				84		52	7
18	36	9	69	10	13			8	87	4	59	2
19	30	10	63	6	11	5		16	84		57	15
20	36	7	65	6	7	8		14	83	2	49	5
21	41	9	69	13	14	4			88		55	6
22	30	9	56	7	8			29	86	10	54	5
23	49	9	78	11	11				59		64	5
24	41	9	59	5	7	8		21	79		52	4
25	33	8	63	5	8			25	92	1	52	10
96	67	9	43		10		22	25	85		44	9
26	55	11	78	8	14				85		48	11
27	30	8	74	13	12				89	7	59	6
28	37	10	74	8	11	7			87	90	48	13
29	41	9	75	11	13				66		57	4

APPENDIX A -- Continued

Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Patient Type as Percent of Total Patients: Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rate	Therapeutic Units Per Diem	Hours of Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
30	37	10	57	7	8			27	84	1	51	5
97	30	7	72	21	7				95		62	1
31	38	6	76	18	4	2			55		69	4
32	36	12	76	7	17				81	8	51	16
33	30	7	59	14	16	12			92	10	49	2
34	44	15	65	6	13	8		9	85	26	52	10
35	31	8	45	6	9			40	87		52	8
36	36	9	58	5	8			29	81	3	52	6
98	41	10	76	14	10				91		56	3
37	32	11	76	8	16				91		58	3
38	44	11	80	8	12				74	45	51	6
39	38	11	81	8	10				87		54	8
40	26	7	67	8	16	7		2	75		47	8
41	44	9	67	5	10			18	82		53	9
42	36	10	75	11	13				77	1	63	3

APPENDIX A -- Continued

Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Patient Type as Percent of Total Patients: Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rate	Therapeutic Units Per Diem	Hours of Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
99	54	9	80	8	12				99	5	55	
43	29	8	68	10	11	12			74		50	2
44	39	7	66	12	13	9			72		64	3
45	26	9	80	8	12				88	1	50	8
46	47	9	71	20	9				90		61	2
47	32	8	68	6	10			17	83		51	9
48	36	11	75	2	23				66		48	1
49	32	7	56	10	22			12	84		46	1
50	19	3	73	8	11			9	85		50	8
51	36	10	66	13	22				81	3	46	8
52	44	12	75	12	13				89		57	
53	41	6	82	9	9				85	3	58	13
54	42	12	61	7	11			21	82		57	10
55	33	10	65	5	8			22	89		56	4
56	32	8	71	8	7			14	73		66	24

APPENDIX A -- Continued

Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Patient Type as Percent of Total Patients: Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rate	Therapeutic Units Per Diem	Hours of Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
57	35	7	69	15	15				84		62	
58	24	10	70	14	16				91		53	6
59	27	11	80	9	11				77		64	6
60	49	7	79	11	10				86		54	17
61	26	11	76	8	16				94		59	6
62	42	10	70	14	16				87		52	7
63	28	9	78	9	13				78		56	6
100	27	6	77	9	13				84		48	7
64	27	9	79	7	14				77		47	5
101	17	6	70	6	6			18	61		45	
65	27	8	72	6	16			6	90		60	6
102	53	11	73	19	8				92		53	6
103	37	12	66	12	21				87		54	1
66	30	8	35	3	11			52	99		26	2
67	23	8	78	9	14				68		54	7

APPENDIX A -- Continued

Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Patient Type as Percent of Total Patients: Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rate	Therapeutic Units Per Diem	Hours Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
104	33	10	77	8	15				71		55	9
68	45	9	99						99		49	16
105	22	9	81	9	10				88		55	1
106	33	10	74	10	16				81		68	2
107	10	6	55	9	11			25	79		40	
69	37	12	51	4	18			28	89		58	4
108	29	8	70	11	19			1	58		58	8
70	44	12	72	19	9				80		66	6
109	24	7	79	6	11			4	72		59	4
71	26	9	70	10	12			9	68		49	3
72	24	3	61	39					76		46	2
73	19	7	67	8	25				57		43	1
110	18	10	79	10	10				83		58	9
74	25	9	80	11	9				95		54	
75	35	10	73	11	17				90		60	19

APPENDIX A -- Continued

Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Patient Type as Percent of Total Patients: Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rate	Therapeutic Units Per Diem	Hours of Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
111	10	8	78	5	17				82		43	3
76	28	8	82	9	9				85		57	9
112	17	7	75	7	9			9	81		51	4
77	25	5	74	8	18				77		33	6
113	26	10	77	13	11				73		63	8
114	10	6	99						84		78	3
115	22	10	74	11	15				53		63	12
116	11	6	67	6	7			21	85		35	3
117	29	6	85	8	7				75		41	2
118	22	7	84	6	11				96		48	11
78	37	9	77	12	11				87		52	5
79	30	11	80	11	9				90		55	
119	25	7	62	6	12			20	98		54	11
120	17	5	65	11	24				97		23	4
121	32	9	81	8	12				99		55	5

APPENDIX A -- Continued

			Patient Type as Percent of Total Patients									
Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rate	Therapeutic Units Per Diem	Hours of Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
122	21	6	82	10	8				69		49	3
123	18	13	64	7	10			20	76		62	2
124	29	2	50	50					85		56	13
125	16	6	74	10	16				79		63	4
126	7	8	66	10	22			2	82		42	
127	13	11	81	6	8			6	68		60	12
80	29	6	76	12	12				93		48	
128	12	6	74	5	8			13	73		66	3
129	18	5	67	8	22			3	99		42	1
81	13	7	68	7	4			21	86		57	11
82	8	5	75	10	15				85		55	3
83	21	6	79	10	11				81		58	
130	25	7	76	13	11				75		50	1
84	21	4	68	6	6			20	84		48	7
131	19	9	83	8	10				80		66	15

APPENDIX A -- Continued

Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Patient Type as Percent of Total Patients: Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rate	Therapeutic Units Per Diem	Hours of Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
132	19	6	73	7	4			16	94		53	
133	15	8	53	6	37			4	84		56	3
134	36	9	80	8	12				73		67	9
135	8	4	89	5	6				72		55	9
85	30	8	86	7	7				77		57	5
136	7	5	76	7	8			10	84		63	3
86	35	11	82	4	14				99		29	7
87	56	9	68					32	99		71	1
137	17	9	86	8	6				75		61	4
138	22	7	73	19	8				83		33	2
88	10	12	51	9	16			24	97		56	
139	43	13	67	7	26				99		17	5
140	8	3	77	6	18				99		35	5
141	6	4	64	16	20				81		60	5
142	34	9	71	13	15				70		66	3

APPENDIX A -- Continued

Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Patient Type as Percent of Total Patients: Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rate	Therapeutic Units Per Diem	Hours of Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
143	5	4	67	12	5			16	60		51	
144	14	3	89	6	6				78		45	13
145	11	8	83	6	5			6	75		39	
146	12	9	67	10	24				97		42	4,
147	13	4	90	6	4				94		49	12
148	5	5	67	6	27				85		37	2
149	18	10	86	6	4			4	99		43	3
150	19	6	78	12	10				73		64	6
151	5	5	77	6	17				96		33	8
152	4	5	76	9	7			8	73		54	8
89	9	7	83	10	7				95		56	6
153												
90	8	5	79	6	16				75		84	3
154	8	7	78	6	16				67		50	2
91	1	6	84	7	9				62		74	4

APPENDIX A -- Continued

Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Patient Type as Percent of Total Patients: Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rates	Therapeutic Units Per Diem	Hours of Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
155	37	7	66	34					87		41	10
156	8	8	79	11	10				84		62	
157	24	8	81	9	10				47		68	4
158	12	5	99						85		70	9
159	8	7	79	9	11				63		84	9
160	24	7	77	9	14				78		60	5
161	7	3	87	6	6				84		59	5
92	13	12	86	5	6			4	77		68	6
162	5	8	82	8	9				67		53	4
163	9	7	84	3	13				76		73	14
164	16	9	71	4	24				99		27	3
165	4	7	80	6	1				69		36	7
166	12	10	70	10	20				51		85	
93	21	8	82	8	11				81		36	
167	21	7	57		43				99		19	5

APPENDIX A -- Continued

Hospital No.	Laboratory Units Per Diem	Radiographic Exams Per Diem	Medicine-Surgery	Maternity	Paediatric	Psychiatric	Convalescent	Chronic	Occupancy Rate	Therapeutic Units Per Diem	Hours of Graduate Nurses As Percent of Total	Private Rooms As Percent of Total
168	26	12	83	10	7				76		50	9
169	25	5	76	11	13				89		66	6
170	11	12	91	4	6				61		45	3
171	7	7	75	6	19				73		34	4
94	36	8	84	8	9				89		58	
95	12	5	64	11	24				65		46	1
172	17	7	82	9	9				69		58	3
173	11	9	65	9	26				76		42	
174	9	4	85	5	10				97		41	7
175	11	5	63	10	28				56		53	
176	2	2	91	5	4				69		48	8
177	7	8	61	8	31				78		42	8
178	33	13	65	19	16				80		72	
179	17	11	76	4	20				76		50	

Calculated From: Ontario Hospital Services Commission, 1965 Annual Reports (Statistical Supplement).

APPENDIX B

WAGE DATA FOR GENERAL HOSPITALS IN THE PROVINCE OF ONTARIO, 1965

Hospital Number	Maid's Monthly Income	Labour's Monthly Income	Nurse's Monthly Income
1	236	271	422
2	195	399	385
3	173	217	445
4	222	326	440
5	191	271	465
6	219	312	447
7	219	312	440
8	180	212	425
9	188		447
10	200	313	445
11	222	326	447
12	191		440
13	184	400	447
14	226	347	437
15	196	305	425
16	219	312	447
17	195		447
18	183		425
19	219	312	447
20	197	343	360
21	178	260	447
22	184	400	447
23	187	253	450
24	190	254	428
25	183		365
26	180	212	432
27	177		397
28	181	240	402
29	188		447
30	178	260	447
31	216	260	437

APPENDIX B -- Continued

Hospital Number	Maid's Monthly Income	Labour Monthly Income	Nurse's Monthly Income
32	219	260	437
33	219	312	447
34	187	253	497
35	201	275	452
36	219	312	447
37	219	312	447
38	187	253	447
39	219	329	447
40	201	275	447
41	219	312	447
42	219	312	417
43	219	329	442
44	219	312	447
45	219	312	447
46	219	312	447
47	219	312	447
48	223		442
49	191		447
50	195	399	447
51	191	271	437
52	200	312	425
53	219	312	447
54	187	321	437
55	200	254	425
56	190	271	428
57	191		465
58	192		440
59	192		432
60	219	312	447
61	178	260	447
62	184		437
63	184		429

APPENDIX B -- Continued

Hospital Number	Maid's Monthly Income	Labour Monthly Income	Nurse's Monthly Income
64	207	271	440
65	236		425
66	199	284	447
67	191	271	465
68	222	326	440
69	219	312	442
70	219	312	435
71		307	448
72			437
73			438
74		307	447
75		329	447
76			384
77			425
78			447
79			437
80			425
81			437
82			408
83			432
84			435
85			
86			400
87			437
88			400
89			410
90			400
91			
92			447
93			459
94			480
95			430

APPENDIX B -- Continued

Hospital Number	Maid's Monthly Income	Labour Monthly Income	Nurse's Monthly Income
96			420
97			440
98			440

Source: A confidential Ontario Hospital Services Commission Wage Survey Report on Hospital Personnel in the Province of Ontario.

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