FINANCIAL MODELING: PRACTICAL APPLICATIONS IN HOSPITAL MANAGEMENT

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A key requirement for success in the practical application of any management sciences technique is a good match-up between the salient features of the technique itself and the demands of the environment in which the technique is used. This is particularly true in financial modeling applications wherein the capabilities of the model are called upon not only to provide management information appropriate to the financial decisions being made, but also to take into account the special characteristics of the entity or process being modeled.

Executives responsible for the administrative and financial operations of hospitals are becoming increasingly aware of the analysis and management benefits which computer-based financial modeling systems can offer in an industry which has long been accused of inefficient service delivery. Once the application requirements and the unique characteristics of the modern health care institution are recognized, the features of computer-based simulation systems can be tailored to respond effectively to the growing complexities of hospital management.

UNIQUE CHARACTERISTICS OF HEALTH CARE DELIVERY SYSTEMS

Virtually all of the major stages in health care delivery are substantially different than the corresponding stages of most other product or service delivery systems. From "product" demand, to delivery, to the receipt of payment, the health care institution is a very unusual entity, and this fact cannot be ignored in the development of a model if the model is to serve management effectively.

DEMAND

In most buyer/seller situations, the level of demand is largely, if not completely, determined by the customer, and the final product selection decision is entirely the responsibility of the customer. In matters of health care, the demand for the services of a hospital is usually created by circumstances not of the "customer's" own choosing. Additionally, the individual hospital selection decision is most often made, not by the "customer", but by the admitting physician depending on where he has admitting privileges. In terms of simulating volume-producing factors, these demand characteristics create a number of problems for the modeler. For example, the modeler must consider all the normal market demand factors such as population, use rates, etc., and then, in addition, modify the results depending on the admitting habits of the staff physicians.

SERVICE DELIVERY

Since the nature and extent of services rendered varies from one patient to the next, patient scheduling is complex. Inpatients occupy beds and receive various combinations of ancillary department services. Outpatients do not occupy beds but they do use a wide range of ancillary department services. Patient charges are accumulated as the patients are processed, and variable costs such as supplies, professional fees, and staffing are incurred. There are varying degrees to which the revenue producing and non-revenue producing departments depend upon each other. Each individual type of inpatient and outpatient visit initiates a unique chain of services, costs and revenues. From a financial modeling standpoint, the flow of patient services and its dollar impact must be understood if the model is to be successful in assisting management to analyze departmental operations, evaluate service programs, and plan for the future.

REIMBURSEMENT

It is the custom in most industries that the seller receives payment directly from the buyer for services rendered. By contrast, more than 80% of the patients admitted to hospitals today carry some form of medical insurance, with the result that most hospitals receive a major portion of their reimbursement from third party payors rather than directly from the patients to whom the services are provided. The modeler, in order to accurately simulate the financial operation of a hospital, must make certain that the particular reimbursement process is properly treated. The modeler must also assure that the interdepartmental cost allocation procedures used by the individual hospital to maximize reimbursement from third party payors are realistically reflected in the model.

PRACTICAL APPLICATIONS OF A MANAGEMENT-ORIENTED HOSPITAL FINANCIAL MODEL

Like any other model developed as a management tool, a hospital financial model must meet all or at least some combination of the basic management requirements. Typically, these include "what-if" forecasting and long-range program planning capability, performance reporting, clerical effort reduction, analysis of key financial data, quick turnaround---all at a reasonable cost.

The power, flexibility, and quick turn-around capability of a computer-based model can be successfully harnessed to meet these general requirements provided that the model is properly constructed to realistically reflect the unique characteristics of a hospital's operations. Accordingly, the hospital financial model should be designed for practical application in the following specific functional areas:

VOLUME OF SERVICE FORECASTING

Major demand statistics such as patient days, physician admissions, occupancy, and average length of stay form the basis for service volumes produced in the routine service (inpatient) departments. The method selected for forecasting should reflect the sensitivity of these statistics to physician activity, available beds, service area utilization rate (usually expressed as admissions per 1,000 population), and the types of inpatient services provided.

The model must also reflect the various relationships which exist between the routine service departments and the ancillary departments in which activity depends upon both outpatient visits and inpatient processing.

STAFFING AND PRODUCTIVITY FORECASTING

Whether expressed in terms of paid hours or full-time personnel equivalents, staffing levels for all job classifications reflect the types and levels of care provided by the individual hospital, and the occupancy trends in that hospital. Payroll costs usually represent the largest single operating cost on the financial statements of a hospital and are a function of staffing levels and wage and salary rates (adjusted for inflation) in the various job classifications within each department. Clearly, the accuracy of a hospital model's output will depend largely on the accuracy with which staffing patterns are simulated in the model logic. In order for the model to perform effectively as a planning tool, the model logic must also reflect the sensitivity of full-time staffing versus overtime to changes in volumes of service within each department.

NEW PROGRAM ANALYSIS

Changing health care requirements and new medical technologies represent external factors which have a major impact on the services provided by a hospital, on the composition of the medical staff which uses the hospital, and on the nursing staff employed by the hospital. Consequently, a hospital model must anticipate management's need to incorporate some form of health care program analysis in the hospital's financial planning system. This implies, once again, that the model must realistically simulate the revenue/ cost/volume relationships that exist within each department of the hospital, as well as the interdepartmental relationships.

REVENUE AND OPERATING EXPENSE FORECASTING

Since each department functions as a cost center, profitability is a concern in the revenue-producing departments, and cost containment is a concern in all departments. Per unit of service charge/cost rates must be accurately developed with adjustment capability to enable hospital management to plan for revenue/cost relationships which will produce adequate levels of operating cash. From a modeling standpoint, the realistic simulation of departmental cost factors requires that fixed and variable costs be separately defined in each department.

One of the major considerations in the development of a hospital financial model, regardless of the model's intended use, is the treatment of the periodic adjustment for reimbursement received by the hospital, from third party payors, in excess of amounts allowable under the terms of the hospital's contractual arrangements with those payors. These arrangements vary depending on the services provided, the type of payor involved, and the state in which the hospital is located. Since most hospitals are on essentially a cost basis for a large percentage of their patient revenues recorded, the dollar amounts of the excess of revenues over cash reimbursement actually received from third party payors is usually substantial. Obviously, even a small error in the simulation of the reimbursement factors could produce significant errors in the model output.

CAPITAL EXPENDITURES AND ALTERNATIVE FINANCING

The public laws which apply specifically to the health care industry require that hospitals maintain both a one year operating budget and a three year capital expenditures budget. In terms of prudent financial management of the hospital, careful analysis and evaluation of the productivity and cost reimbursement effect of capital asset acquisitions are mandatory.

Because of the sometimes conflicting need to invest in assets which will support future service programs while at the same time preserving current operating cash, hospital management needs access to information which will quantify the likely outcome of prospective investment alternatives.

PERFORMANCE REPORTING AND FINANCIAL STATEMENT ANALYSIS

One of the functions of a management information system is to permit management to monitor actual operating results by making meaningful comparisons

to forecast operations. Although such performance reporting capability need not be an integral part of the model itself, the model must at least provide adequate forecast information and analysis to enable hospital management to make informed planning decisions and to make subsequent comparisons with actual results.

Financial analysis in a hospital environment is most effective when performed at two distinct levels--at the more detailed departmental level and at the consolidated level of the overall financial statements. The reason for this is that most of the direct and controllable revenues and expenses are generated within the departments, yet a number of other significant revenues and expenses (such as depreciation, interest income and expense, bad debt write-offs, etc.) occur beyond the control of the individual department heads. Accordingly, a hospital financial model must be capable of performing various profit center analyses for each department, then subsequently summarizing the departmental data, combining it with other hospital financial transactions, and computing the key indicators required for overall measurement of the hospital's performance.

DEVELOPMENT OF A FINANCIAL PLANNING AND BUDGETING MODEL AT L. W. BLAKE MEMORIAL HOSPITAL

The task of developing a computer-based financial model was undertaken by the management of L. W. Blake Memorial Hospital in Bradenton, Florida, for the purpose of improving the flexibility and timeliness of the budgeting and forecasting portions of the Hospital's management information system. The methodology used in the development of the model, and results achieved are outlined below. Examples of the output and capability of the model at the departmental level are shown in Exhibits I, II, and III.

METHODOLOGY

Although the analysis was extensive, the major procedures can be summarized as follows:

- Identification of the specific objectives of the model. Of these, the most critical to the construction of the model were the capability to combine in one model, the detailed budgeting and planning requirements of the individual department heads with the more comprehensive "what-if" requirements of top management.

- Identification of the key indicators needed by management at various levels for decision making. Ranging all the way from cash provided by overall hospital operations to productivity per employee in each department, the various measurement criteria had to be defined at the outset.

- Definition and acceptance of the reporting format. To assure that the output format would be meaningful to and understandable by all who would receive it, a number of proforma examples were reviewed before a mutually acceptable one was agreed upon and before construction of the model logic.

- Recognition of departmental and account interrelationships. In order to effectively simulate the financial operation of the routine and ancillary departments as well as the transactions which occur outside the departments, it was necessary to historically track the changes in the various volumes of service and related financial impact. Once the independent variables were recognized and their relationships with the dependent variables defined, the logic could be constructed and tested using an historical year's data as part of the initial forecast. Since the Hospital frequently redistributes its patient load among the beds available, certain algorithms had to be built into the model to allow for considerable fluctuation in the number of beds available and their use.

- Definition of staffing patterns. Historic patterns of hours worked, rates, cost of living and merit raises, and employee benefits were defined in relation to volumes of service in each department. To permit staffing optimization for planning and comparison reporting purposes, a model logic routine was developed to compute the optimum mix of full-time equivalents and overtime add-ons as volumes of service fluctuated in the various departments.

- Determination of the lowest level of detail required. Since "overbuilding" of detail in the logic and data makes a model as unwieldy as "underbuilding" renders it useless, careful attention was directed to developing the model to accommodate only that level of detail which was required for the management decision criteria identified.

- Selection of the model language. Once the various tasks to be performed by the model were described and the size of the matrix defined, the decision was made to use an appropriate modeling language in a time sharing environment. A major consideration in this decision was the desire of the Hospital's management to avoid the time, effort, and cost required to program and maintain the entire model on in-house equipment when adequate modeling languages were commercially available at reasonable cost.

RESULTS

To meet the key management objectives, a modular model was developed wherein a departmental module was designed to operate separately from the overall top financial statement module. This has the advantage of enabling users at both the department

head level and at the top management level to do preliminary forecasting, budgeting, and planning independently prior to consolidation and subsequent review. The only restrictions applied to both levels simultaneously are the common denominators required to prevent chaos i.e., the same major demand statistics such as patient days and emergency room visits are used by all parties, and the model logic works identically in all departments. Thus, in order to budget a significant variance in volume for a given department, the department head would have to change the intensity factors which relates his department's volume to the appropriate major independent variable (and justify the change) - the demand statistic itself could not be changed unless it were changed for all departments.

This modular design enables the department heads to 1) become involved in the model development, 2) substantially reduce the time spent in the development, review and revision of the departmental budgets and, 3) test the impact of alternative operating plans on the various performance measurement indicators by testing successive iterations in a "what-if" mode prior to selecting the one to be forwarded to top management for approval.

The model enables top management to 1) similarly test alternative operating plans, 2) spend more time making management decisions and less time on clerical work, 3) conduct a more meaningful review of departmental budgets and, 4) consolidate departmental budgets with the assurance that the budgets are mathematically correct and prepared consistently from one department to the next.

In terms of planning and forecasting the overall Hospital operations, top management can perform any type of analysis with the financial statement module without the need to first run the departmental module simply by making assumptions about the combined departmental revenue and expense totals and entering the assumed totals as data input. However, in the final analysis, the assumed totals need to be removed, and actual departmental totals entered--this can be done manually or automatically. Consequently, if management decides on an overall plan which requires departmental totals different from those which are actually provided by the department heads, a rerun of the departmental module would be necessary with the departmental data changed accordingly.

From the standpoint of realistic financial simulation, one of the major features of the model is its capability to accurately compute contractual allowances, i.e., deductions from revenue representing excess of recorded revenues over actual cash reimbursement received from third party payors. Since this reduction of revenues changes automatically with every change in any reimbursable item in the financial statements, management can run the model for any "what-if" question and be confident that the resulting output accurately reflects the new contractual allowances and other deductions from gross revenue.

Although the model is basically a "forward going" simulation device driven by various volume of service factors, the design includes the capability for performing backward iteration analysis. For example, the model can answer the question "How much gross revenue does the radiology department need to generate in order to achieve a net profit of $200,000?" The model will compute the required gross revenue, change the staffing and other expenses appropriately to maintain built-in relationships defined in the logic, and produce the new radiology department income statement resulting in the targeted net profit. This same analysis can be performed in any department or in the top financial statement module.

Exhibit I shows the results of a base forecast run of the model for one of the nursing service departments. Our tests of correlation indicated that the major variable dollar items and full-time equivalents in this department were more sensitive to changes in patient days than to any other volume variable and consequently this statistic was chosen to represent volume of service. It was decided by Hospital management that variations in patient acuity would not be addressed in the model other than through patient days.

Revenue represents the extension of patient days and inflation-adjusted rates per day without consideration of contractual allowances which are treated in the financial statement module. For purposes of measuring more accurately the performance of individual departments, management elected not to include third party payor adjustments in the departmental module.

Salaries and related payroll expenses are a function of the budgeted optimal number of full-time equivalents (based on required hours for the volumes of service shown) and inflation-adjusted wage rates. Supplies expenses are generated by applying inflation-adjusted per-unit cost rates to the volumes of service. All other expenses are direct inputs to the model and represent costs which are classified as fixed except for inflationary adjustments.

The residual profit margin reflects the department's contribution to hospital overhead, i.e. operating revenue available to meet such hospital-wide expenses as depreciation and interest, as well as the costs of the non-revenue producing departments.

In order to permit each department head to determine the effect of any data input changes on the various performance indicators, the model is designed to calculate and print out these indicators at the bottom of each departmental income statement. Profit margin is expressed as a percent of gross revenue, and revenues, expenses and profit are all expressed as values or aggregate rates per unit of service.

Revenue per standard manhour is significant to revenue producing departments in this hospital in terms of measuring return on human resources employed in service delivery. This indicator represents the product of units of service and historic manhours-per-unit divided into gross

revenues. As a further measure of productivity, the model computes the optimum mix of full-time equivalents and part-time add-ons required ("computed FTE's") based on the actual volume of services provided, and compares the result with actual or budgeted full-time equivalents. This comparison is expressed as "percent staffed". In this manner the per unit productivity of the human resources employed is separated from dollar return which is sensitive to both productivity and the price of services.

Exhibit II demonstrates the effect of performing a backward iteration in which a net profit of approximately $800,000 is targeted for the first year of the forecast based on a change in patient day charges only. The model calculates the new per diem charge required to generate the required bottom line figure and produces a new department income statement. Although this is a simple calculation at the department level, it becomes far more complex in the financial statement module in which contractual allowances must be considered.

Exhibit III illustrates the same backward iteration technique applied for the first year of the forecast in response to the "what-if" question: "How many patient days must be generated in order to produce a target net profit of approximately $800,000 in 1976-77 with all other assumptions constant?" This computation is somewhat more complicated than the previous calculation since a volume change produces a number of subsequent changes such as an increased level of staffing, higher variable costs, etc. Although patient days is not a variable which is controllable by the department head, hospital management frequently asks questions involving changes in forecast or budgeted patient days.

SUMMARY AND CONCLUSIONS

The L. W. Blake Memorial Hospital model is functional for the intended applications, and meets the requirements for the practical application of a management sciences technique. The model contains only those capabilities required in the situations in which it is used and, although the model can be modified to meet other requirements, it is by no means intended to represent an all-purpose hospital model.

Clearly, modeling has a wide range of applications as a management sciences tool within the health care field, and these applications are not limited either to the financial aspects of health care delivery, or to the hospital entity itself. For example, the use of computer-based simulation should be seriously considered by agencies responsible for areawide health care planning.

One of the major barriers to the development and use of modeling as a management science technique in the health care field has been a lack of understanding of the benefits modeling can offer, and an overestimation of the difficulties involved in developing and using a model. Future government regulations will exert increasingly more pressure on the health care industry to plan for the future and to control current operations. As this pressure develops, it will become imperative for the industry to explore more sophisticated management techniques. Computer-based modeling stands out as an excellent management sciences methodology with which to respond to these pressures.

EXHIBIT I

L. W. BLAKE MEMORIAL HOSPITAL

FOURTH FLOOR NORTH NURSING UNIT

BASE FORECAST

	1976-77	1977-78	1978-79
UNITS OF SERVICE			
Patient days	13,757	13,486	13,478
REVENUE			
Total revenue	$1,110,878	$1,176,114	$1,269,450
EXPENSES			
Salaries	359,140	378,873	405,064
FICA	21,728	22,922	24,506
Medical, surgical, lab supplies	12,244	12,842	13,734
Office supplies	4,835	5,087	5,443
Continuing education	945	982	1,051
Dues, subscriptions, books	175	182	195
Repairs and maintenance	2,500	2,675	2,862
TOTAL EXPENSES	401,567	423,563	452,855
PROFIT MARGIN	$ 709,311	$ 752,551	$ 816,595
% profit margin	63.9	64.0	64.3
Revenue/unit of service	80.75	87.21	94.19
Expense/unit of service	29.19	31.40	33.60
Profit/unit of service	51.56	55.80	60.59
Revenue/standard manhour	15.24	16.45	17.77
Bed utilization	96.6	94.7	94.7
Manhour/unit of service	5.3	5.3	5.3
Actual employees	38	37	37
Computed FTE	38.05	37.36	37.34
% staffed	99.8	98.9	99.0

EXHIBIT II

L. W. BLAKE MEMORIAL HOSPITAL

FOURTH FLOOR NORTH NURSING UNIT

BACKWARDS ITERATION #1

	1976-77	1977-78	1978-79
UNITS OF SERVICE			
Patient days	13,757	13,486	13,478
REVENUE			
Total revenue	$1,201,536	$1,176,114	$1,269,450
EXPENSES			
Salaries	359,140	378,873	405,064
FICA	21,728	22,922	24,506
Medical, surgical, lab supplies	12,244	12,842	13,734
Office supplies	4,835	5,087	5,443
Continuing education	945	982	1,051
Dues, subscriptions, books	175	182	195
Repairs and maintenance	2,500	2,675	2,862
TOTAL EXPENSES	401,567	423,563	452,855
PROFIT MARGIN	$ 799,969	$ 752,551	$ 816,595
% profit margin	66.6	64.0	64.3
Revenue/unit of service	87.34	87.21	94.19
Expense/unit of service	29.19	31.40	33.60
Profit/unit of service	58.15	55.80	60.59
Revenue/standard manhour	16.48	16.45	17.77
Bed utilization	96.6	94.7	94.7
Manhour/unit of service	5.3	5.3	5.3
Actual employees	38	37	37
Computed FTE	38.05	37.36	37.34
% staffed	99.8	98.9	99.0

EXHIBIT III

L. W. BLAKE MEMORIAL HOSPITAL

FOURTH FLOOR NORTH NURSING UNIT

BACKWARDS ITERATION #2

	1976-77	1977-78	1978-79
UNITS OF SERVICE			
Patient days	15,466	13,486	13,478
REVENUE			
Total revenue	$1,248,879	$1,176,114	$1,269,450
EXPENSES			
Salaries	401,882	378,873	405,064
FICA	24,313	22,922	24,506
Medical, surgical, lab supplies	13,765	12,842	13,734
Office supplies	5,159	5,087	5,443
Continuing education	1,053	982	1,051
Dues, subscriptions, books	195	182	195
Repairs and maintenance	2,500	2,675	2,862
TOTAL EXPENSES	448,867	423,563	452,855
PROFIT MARGIN	$ 800,012	$ 752,551	$ 816,595
% profit margin	64.1	64.0	64.3
Revenue/unit of service	80.75	87.21	94.19
Expense/unit of service	29.02	31.40	33.60
Profit/unit of service	51.73	55.80	60.59
Revenue/standard manhour	15.24	16.45	17.77
Bed utilization	108.6	94.7	94.7
Manhour/unit of service	5.3	5.3	5.3
Actual employees	42	37	37
Computed FTE	42.41	37.36	37.34
% staffed	96.7	98.9	99.0