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EDITOR'S NOTE:

An article in the February 2014 issue of *OR/MS Today* described enterprise optimization as "a framework that seamlessly integrates management accounting's principles with significant advantages for managers." The article outlined two management accounting principles required to achieve enterprise optimization: 1) the causality principle (i.e., cause and effect modeling), and 2) the analogy principle (using cost information to accurately reflect operational business activities) [1]. That article was an elaboration on an earlier article, "A Managerial Costing Conceptual Framework" published by IMA in March 2013 [2]. However, neither article described any specific enterprise optimization applications. That is the purpose of this article.

OIS represents the first time OIS' analytics, both of which are in widespread use today, have ever been integrated.

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Enterprise optimization: a new application

The demand-driven operational income statement (OIS) integrates prescriptive optimization and predictive analytics.

By Alan Dybvig and Gary Cokins

The demand-driven operational income statement (OIS) application integrates two advanced analytic techniques: prescriptive optimization (i.e., what is the best possible outcome?) and predictive analytics (i.e., what will happen if we do X?). OIS employs optimization, to the best of the authors' knowledge, for the first time to financial flow variables (i.e., the income statement) and not, as traditionally been the case, to the stock variables of the balance sheet [3]. This is important because as Randall Bolton comments in his book, "Painting with Numbers," the income statement is "The one report every organization needs." In fact, he devotes an entire chapter to it.

In addition, OIS represents the first time OIS' analytics, both of which are in widespread use today, have ever been integrated, specifically, Operations (i.e., supply chain network design) and Sales/Marketing (i.e., marketing-mix modeling). The former makes OIS operational and the latter makes OIS demand-driven.

The result, with Finance's leadership and featuring Sales/Marketing's analytics as the driving force, is a powerful, new form of the income statement, one that assures important cross-functional performance management benefits for the entire enterprise.

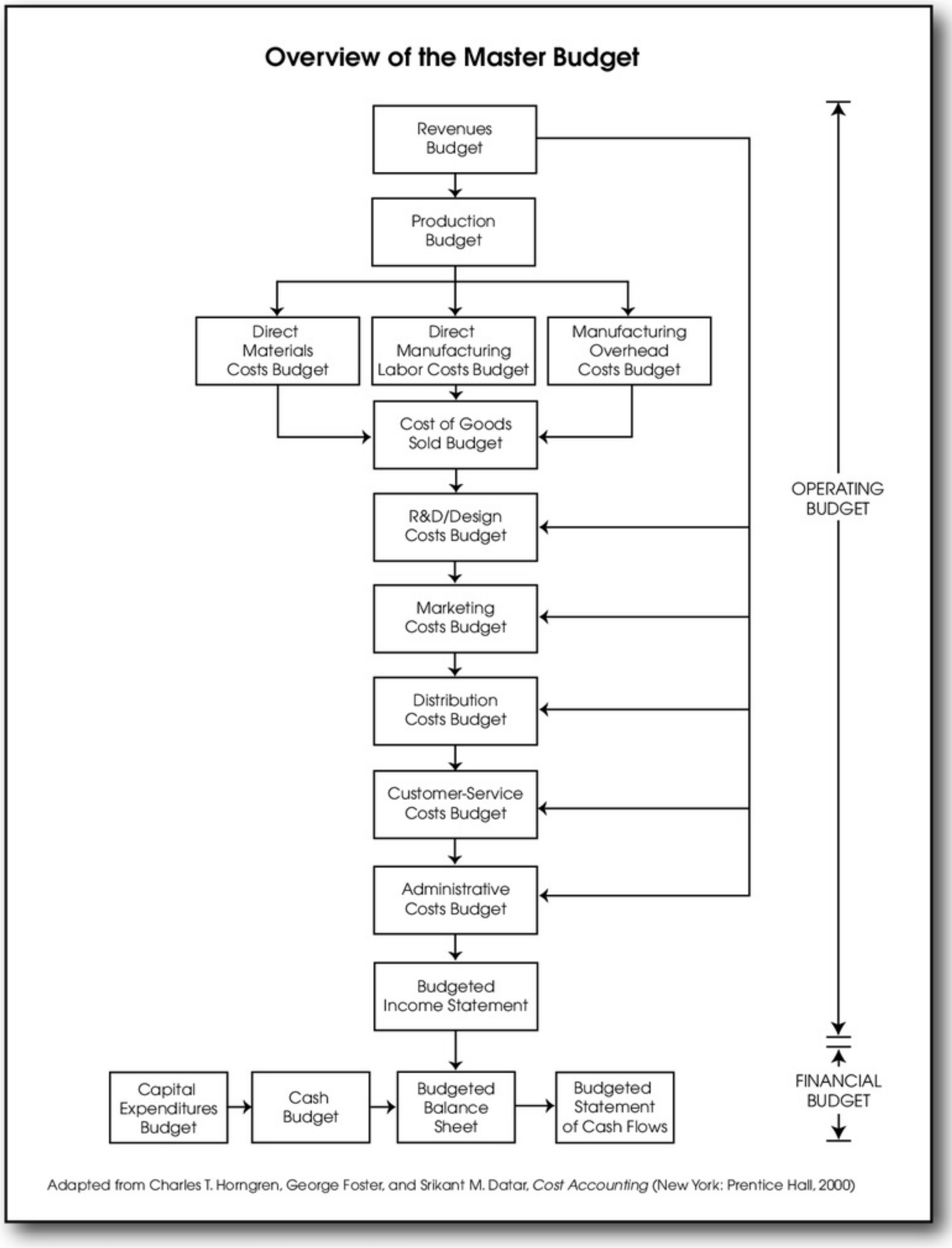

Figure 1: Overview of the master budget.

Current Applications

Budgeted income statement. As illustrated in the master budget flow chart in Figure 1, the traditional income statement is developed from the budget, beginning with the revenues budget (forecasted level of unit sales) as the starting point.

Marketing-mix modeling. Traditionally, demand is the critical independent variable in the annual planning process. As illustrated in Figure 1, it is demand as expressed in the forecast that drives the process. However, the essence of marketing-mix modeling is the opposite, where demand is treated as a *dependent variable* driven by sales and marketing expenditures.

One of the authors first encountered the marketing-mix modeling concept more than 10 years ago while doing research for what has become the product that creates the OIS. The article, by John D.C. Little, describes an online model for use by product managers on advertising budget questions [4]. The objective was to size and allocate advertising expenditures, and the model was called, appropriately, ADBUDG.

In the article, Little describes the data required for generating the "sales response to advertising function" and its shape. Interestingly, the mathematical expression in this model remains the most common one 35 years later, though for reasons discussed below the data are no longer qualitatively developed.

Several people then went on to extend Little's work to other promotional elements than advertising. For example, Lodish, et al. extended it to the sales force in an article titled, "Sales Force Sizing and Deployment using a Decision Calculus Model at Syntex Laboratories" [5].

Since their original formulation, Little's "Sales Response to Advertising Functions" have become increasingly more powerful and more sophisticated. Now referred to as response functions, they are now quantitatively developed [6] and have become more accurate for the following reasons:

1. Availability of more accurate and complete data on sales (e.g., scanner data at checkout provided by firms like IRI and Nielsen) and tracking of activities (e.g., digital promotions)
2. Vastly improved computing power
3. Individual promotional elements of total sales and marketing expenditures extended to include more than one element (e.g., print, TV, digital, sales force)
4. Individual sales and marketing elements extended to include econometric ones (e.g.,

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weather/environment, economic, industry trends and competition)

These decision calculus applications are now broadly referred to as marketing-mix modeling (MMM). MMM is defined in Wikipedia as, "Marketing mix modeling (MMM) is statistical analysis such as multivariate regressions (predictive analytics) on sales and marketing time series data to estimate the impact of various marketing tactics (marketing mix) on sales and then forecast the impact of future sets of tactics. It is often used to optimize advertising mix and promotional tactics with respect to sales revenue or profit."

Details of the current state of marketing-mix modeling efforts can be found in IRI's brochure, "Success and Failures in Marketing-Mix Modeling" [7]. Details on the use of marketing-mix modeling techniques, focused exclusively on the sales force, are available in the article, "Sales-Force Decision Models: Insights from 25 years of Implementation" [8].

Supply chain network design. Supply chain network design is a key business function that has increasingly gained the attention of senior management. Modern supply chains are complex global networks of suppliers, manufacturing and distribution facilities, ports, third-party providers, transportation choices and inventories that are impacted by rapidly changing market conditions, competitor initiatives, disruptions, currency fluctuations, regulatory issues and so on. Supply chain networks must be re-evaluated on an ongoing basis (at least annually) in order to balance revenue growth, costs, working capital, asset deployment and sustainability objectives.

Remarkably, even today many executives equate supply chain strategy with the number, location, size and mission of distribution centers. This view is shortsighted. Consider the following contemporary list of strategic issues that a network design tool can be used to analyze:

Facility issues

(types: supplier, manufacturing, DC, cross-dock, port)

1. Number, size and location
2. Ownership
3. Mission

- raw material supplier procurement volumes, costs and limits;
- plant location manufacturing volumes, costs, capacities and inventory requirements;
- distribution center throughput and storage levels, operating costs, throughput and storage capacities and inventory requirements; and
- port, cross-dock and pool throughput levels, operating costs and throughput limits.

Major policy issues

1. Strategic sourcing
2. Target market expansion including international
3. Supply chain vulnerability, capacity, seasonal demand/supply and sustainability measurement and objectives including energy and carbon usage profiles
4. Mergers and acquisitions
5. Transportation policy
6. Inventory strategy
7. Customer profitability and cost-to-serve

Because of the all but infinite possible solutions to these design issues, mathematical programming prescriptive optimization techniques are required, in this case a mix of linear and integer programming (MILP). For more details, the interested reader is referred to "Modeling the Supply Chain," Chapter 4 [9].

OIS' Functional Benefits

For Finance, OIS:

- Creates the maximum profitable forecast displayed in the operational income statement.
- Integrates the executive team's strategic plan with the annual financial plan (Their strategy is typically disconnected from a traditional budget.)
- Maximizes the projected OIS profit opportunity of a proposed merger and acquisition (M&A) deal.
- Does not disrupt or replace any of the enterprise's currently installed operational and financial planning and execution software systems (e.g., FP&A, S&OP).
- Improves the forecast process and its results.
- Enables the creation of a flexible OIS. (Definition from Accounting.com: "A flexible budget is a budget that adjusts or flexes for changes in the volume of activity"). This is useful for actual vs. budgeted cost variance analysis [10].
- Enables a strategic OIS to be developed using the same model structure as the annual OIS. This presumes that the firm is comfortable with the accuracy of cost data in the strategic time frame and forecasts for the strategic time frame beyond a year.

For Sales and Marketing, OIS:

- Maximizes the return on investment (ROI) of the expenditures by the Sales and Marketing departments.

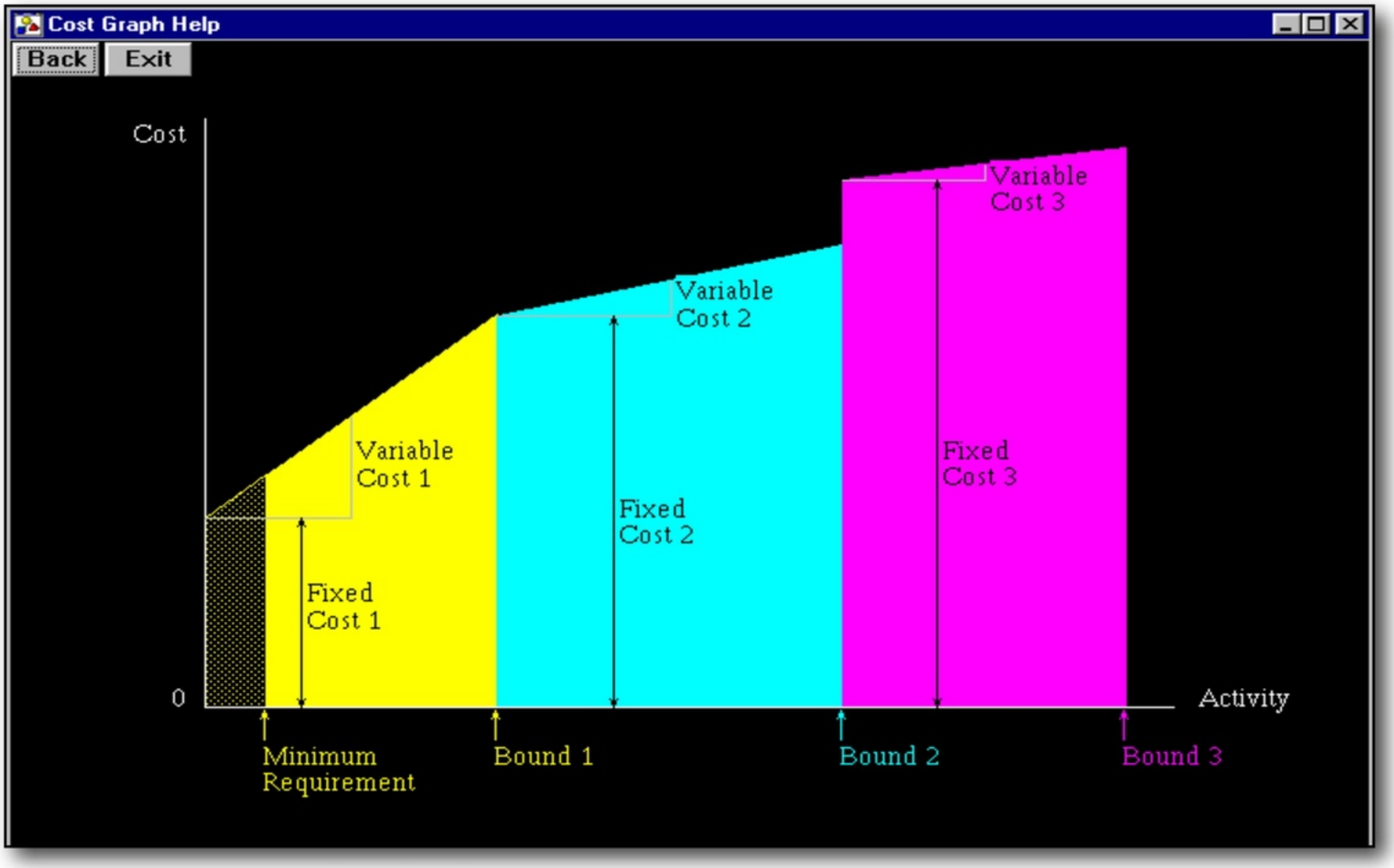

Figure 2: Three cost elements used for COGS and G&A.

- Enhances marketing-mix modeling applications for firms that are currently using them.

For Operations, OIS:

- Designs the optimally feasible supply chain plan required to make and fulfill continuously revised forecasts respecting sustainability constraints of energy and carbon emissions, if desired.
- Redesigns the strategic supply chain as a part of developing the strategic plan thus making it truly optimal. Most supply chain network designs are sub-optimal because they all assume a fixed forecast of product volumes. As explained in the Model section, the OIS relaxes this assumption. Thus, the OIS supply chain is truly optimal because of the concept of sub-optimization [11].
- Possibly, provides an optimal solution for the vexing issues of stock keeping unit (SKU) proliferation and the omni channel [12].
- Is easier to build if the firm has activity-based costing data.

A variety of financial trade press articles confirm the trend of CFO leadership in cross-functional analytics and greater involvement with Operations [13].

The OIS Model

The OIS contains three cost elements: 1) all the operations performed by the firm, 2) the buildings within which the operations are performed, and 3) links connecting the buildings. Importantly, since an OIS answers the "best possible outcome" question (in the OIS' case, the most profitable forecast), then the costs of these three elements must be represented in the model as variables so the model can calculate and select the best outcome from all the possible solutions. These three cost elements are arranged sequentially in echelons from procurement to the customer in a prescriptive mathematical programming model (MILP) as described above.

The three cost elements used for the cost of goods sold (COGS) and general and administration (G&A) operations are referred to as cost functions. They are a mathematical relationship describing how costs (y axis) vary with changes in the operation's quantities (x axis) and are an example of single variable (univariate) predictive analytics (see Figure 2).

There are at least four ways for management accounting practices to work with Operations to

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create these functions: statistics, engineering data, accounting records and, as was only recently utilized by progressive accountants, with activity-based costing data [14].

The final element of an OIS, Sales, is more complicated. These cost relationships are referred to as enterprise response functions. They are an OIS' third use of advanced analytics and are also Stage 3 in the analytics continuum – predictive analytics. Enterprise resource functions differ from cost functions; specifically, they reverse the x and y axis relationship of the cost functions. The independent variable, the horizontal axis (x), is the total sales and marketing expenditures, and the dependent variable, the vertical axis (y), is the quantity that those expenditures drive.

Deriving the enterprise response functions often requires much more sophisticated analytics than the cost functions. As discussed briefly above, the amount of demand generated by sales and marketing expenditures are a function of many different factors: prior customer satisfaction with the goods, the amount and effectiveness of marketing, the level of competition, pricing and discounting, external events (like weather), etc. Advanced analytic techniques, such as those used for marketing-mix modeling, are available to estimate the enterprise response functions [15]. Companies will also need to have access to experienced practitioners who can build and validate these models unless the companies already possess a demand signal repository and can implement demand signal analytics. These enterprise response functions are an example of multivariate (more than one independent variable) predictive analytics. A variety of firms are available for assistance with enterprise response function development including ZS Associates, MarketShare, Hudson River Group, Marketing Management Analytics and Analytic Partners.

Unlike cost functions that will bring the management accountants closer to Operations, enterprise response functions will bring them closer to Sales and Marketing. Further, as described above, since the enterprise response function's dependent variable – cost – is the independent variable in cost functions, then enterprise response functions drive the entire OIS model. Thus, Sales and Marketing's expenditures are the cause that drive COGS + G&A costs. This is a reality that will elevate the importance of Sales and Marketing's role in the annual planning process.

A final point needs to be emphasized: the OIS works. A simplified model was created by a consulting firm using data from an activity-based costing system. Its results determined the firm had left 25 percent to 150 percent profit on the table [16].

As an example of enterprise optimization, OIS is well positioned to be of interest to many as a new, powerful form of the income statement, "The one report every organization needs." Further, it positions the CFO very well in light of emerging CFO leadership trends in terms of advanced analytics and operational matters.

In these times of ever increasing competition, volatility and an uncertain economic outlook, investigating and evaluating whether an operational income statement would benefit organizations should be an imperative. It would likely constitute an enduring competitive advantage. ORMS

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