feature article

Enterprise Master Plan: Next-Generation Planning With Activity-Based Costing

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Imagine relaxing the assumption of a fixed sales forecast to solve for the optimum level of sales and marketing spending that will provide the maximum profit and return on investment. This article and case study explains how. © 2015 Wiley Periodicals, Inc.

Ten years ago the Consortium of Advanced Management International (CAM-I), an acknowledged leader in activity-based costing, published *The Closed Loop*,[1] one of the first books on activity-based planning and budgeting (ABPB). Since that time, most activity-based costing (ABC) software providers have added additional capability and application for ABPB. Starting with a fixed sales forecast and sales/marketing spend, almost all of the operating data required for the ABPB is readily available in most ABC models.

What's been missing is the ability to optimize a plan based on a level of sales and marketing spending that will provide both the maximum profit and return on investment. No longer is that true. The next generation is enterprise master planning (EMP), where both the optimized forecast and supply chain are solved simultaneously to maximize profitability and the return on investment, as illustrated in the graphic representation set forth in Exhibit 1.

There are five factors necessary for developing a maximally profitable annual plan:

1. The *forecast* must be variable in the driver-based plan model.
2. The *supply chain* must be variable in the driver-based plan model.
3. The *objective function* (i.e., what you're trying to optimize) must be profit.
4. The *solver* must be prescriptive ("what is the best *X*?") and not scenario analysis ("What will happen if we do *X*?").
5. The model must be solved *simultaneously* to develop an EMP that incorporates all five factors.

Specifically, the EMP is created using modeling software that integrates three planning techniques, all of which have been commercially available for decades:

1. Supply chain network design
2. Activity-based costing
3. Marketing-mix modeling

The supply chain software relaxes the assumption of a fixed supply chain, uses profit as the objective function, and has a prescriptive solver. ABC models provide the data for the cost functions in an EMP by which the assumption of a fixed supply chain are relaxed. ABC cost functions are more conveniently developed than those traditionally developed and are the reason the case study example could be developed as described below. Finally, the assumption of a fixed sales (units) forecast is relaxed by response functions developed in traditional marketing-mix modeling software.

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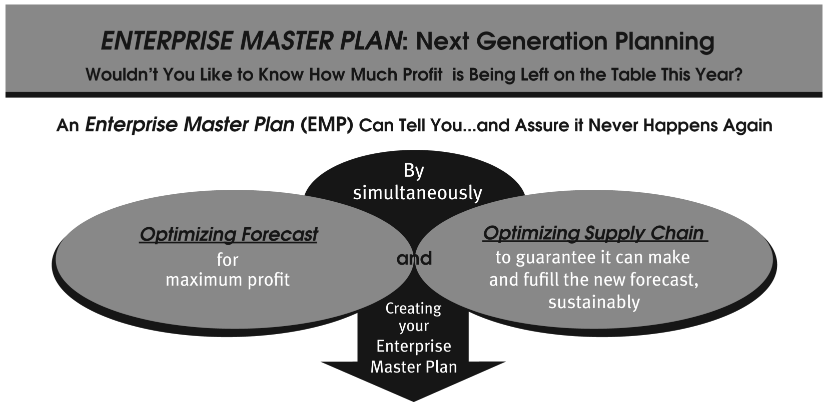
Exhibit 1



The resulting EMP mathematically assures that the enterprise's other planning applications—e.g., financial planning & analysis (FP&A), sales and operations planning (S&OP), and marketing mix modeling—*are* aligned to a maximally profitable forecast and an optimally feasible supply chain.

The power of an EMP was confirmed through a simplified proof-of-concept (POC) case study based on ABC data previously developed by one of the authors. When optimized (and depending on the specific scenario), profit improvements of 25 to 75 percent would have been possible. Thus, this modeling can be justifiably described as "revolutionary."

BACKGROUND

There are two ways to determine the optimal solution for financial and operations planning. One is termed *descriptive* (also referred to as scenario analysis or enumeration). It answers the question: What will happen if we do *X?* The second is termed *prescriptive* or *normative*. It answers the question: What is the best *X? Normative* techniques are much more mathematically sophisticated and are required when the number of possible scenarios is too numerous to analyze descriptively. For any realistic and viable number of possible alternatives, descriptive techniques are a suboptimal solution.

Thus, rather than scenario planning to calculate *X* for each individual selected scenario, the *future* is about solving for the best *X* by looking at every single combination of sales volumes, costs, constraints (e.g., capacity) and sales and marketing spending that results in the highest profit and return on investment (ROI). In many ways, this is as good as it gets for financial and operations planning.

Optimizing profit and financial return by relaxing both the assumptions of a fixed forecast and a fixed supply chain requires an integration of predictive analytics that describe how products and services respond to marketing and sales spending (i.e., response functions) and prescriptive mathematical programming techniques used for among other things, supply chain network design. The current practice of supply chain network design uses a mathematical programming technique that is a mix of integer and linear programming (MILP). It has been applied successfully for more than 40 years, since the commercialization of mathematical programming techniques developed originally by George Dantzig.

The MILP technique has been used to solve "long lead time" (i.e., a year or more) supply chain design questions such as mergers; the number, location, and size of raw material suppliers; manufacturing facilities; production processes; distribution centers; and cross-docks. It has also been used to address shorter lead time questions (i.e., from days up to a year).

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Examples include capacity planning, distribution methods and policies, and inventory analyses.

The open question is whether the integration of response functions into a supply chain network design modeling software would work. Would it actually demonstrate a profit and ROI improvement? Since the software to create an EMP existed, the question quickly became would the data have to be made up or did data already exist from which a Proof of Concept (POC) case study model could be built.

The answer was a surprise to all the authors: an existing ABC model. This is because, as it turned out, the critical cost functions required to build the EMP were readily created from previously built ABC models. Thus, importantly, many of the existing ABC models are ready-made for building EMP case study POC model. This is because all the drivers in ABC models are units (i.e., activities). These force the development of the associated ABC planning factors required to drive the costs to the units, including:

- Activity consumption rate (ACR)
- Resource consumption rate (RCR)
- Cost factors (CF)

These planning factors are precisely what an EMP model needs for its cost functions. Two seemingly unrelated modeling techniques, activity-based costing and supply chain network design, turned out to have exactly the same cost-modeling architecture.

Thus, when CAM-I published its very detailed, groundbreaking book *The Closed Loop,* describing how the ABC planning factors (ACR, RCR, and CF) could be used for planning purposes, the stage was set, 10 years later, for the capability to optimize the closed loop by relaxing its assumption of both a fixed forecast and a fixed supply by applying MILP optimization techniques.

CASE STUDY: COMPANY AND ITS FINANCIALS

The POC case study was the McCoy Belt Buckle Manufacturing Company, which makes an iconic brand of belt buckles sold to distributors and corporate customers located all over the globe. Total annual production of belt buckles is about 17 million. There are two lines of belt buckle products: standard and custom. Standard products include tong, snap, and clip. Custom products start with a standard clip belt buckle that is then engraved, embossed, or decorated.

McCoy was selected for this case study because they had an existing ABC system in place and were willing to participate and be part of the project team. The thousands of product stock-keeping units (SKUs) were reduced to two broad product groups (i.e., custom and standard), and three sales areas (North America, Europe/Middle East, and Far East). This, in turn, created the need for six response functions, about which McCoy had some knowledge and experience.

Like most companies, McCoy used the base-year financial results as a starting point for developing the operating plan and budgets for the upcoming year. An overall summary of the McCoy reported financial results for the base year is set forth in Exhibit 2.

Like most budgeting exercises, this was a bottom-up plan that started with a revenue projection from the sales department. Operating managers use this sales projection to develop the manufacturing plan. This business is seasonal: A large part of revenues is from shipments in the third quarter to retailers ramping up for the holiday season. Marketing and sales bases its spending on estimates of promotional materials, displays, incentives, and the advertising required to achieve the sales target. General and administration budgets are made by managers based primarily on the previous years with adjustments to account for the higher level of sales. Each manager prepares, reprepares, negotiates, and renegotiates his individual budget, which is complete when approved. Add it all up and you have the company operating plan and budget.

Was it a good plan? Yes. Was it optimized for the highest profit and ROI? No. The number of possible solutions to any realistically sized model would generate an absurdly large number of possible solutions that would have to be evaluated individually, by scenario analysis. In optimizing an operating plan, billions of combinations of sales, costs, capacity, and sales and marketing spend are used to identify those specific combinations that result in the highest profits and ROI.

The rest of this article describes how McCoy's activity-based costing data were used to build a simple functional model of the base-year financial and operational results. This model, in turn, when optimized, illustrated profit opportunities in the range of 25 to 75%. Profit

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had in effect been left on the table.

Sales

Total units for the base year were 16.5 million, and the average selling price for all products was $8.20. Selling prices for individual products range from $7.05 to $10.65. The total number of customers is about 2,500, mostly distributors who sell to retail stores. The largest area is the United States, making up just over half of total unit sales. The next largest is Europe/Middle East, which together account for 28 percent of total sales. The Far East region makes up the remaining sales.

Cost of Goods Sold

Direct material is about 72 percent of the total cost of goods sold. All belt buckets go through standard manufacturing processes that include fabrication, buffing, and plating. Customized belt buckles require additional manufacturing processes for engraving, embossing, or for decorating. The last manufacturing process is to package each belt buckle in a 4-by-6-inch box. Using ABC, the company was able to define the cost of unit of output for each of the manufacturing processes. The combined total of all manufacturing processes was $19.8 million.

Support processes ($9.3 million) included engineering support (custom design, quality control/inspection, and material testing), manufacturing support (facility maintenance, machine maintenance, custom machine maintenance, product moves, and custom product moves), and manufacturing administration (basic procurement, custom procurement, and production control).

Direct material and the costs of each of the manufacturing and support processes were expressed as a cost per unit of process/activity output, and each were rated for capacity and to identify constraints. A determination was made between fixed and variable costs for each process.

Shipping and Warehouse

Shipping and warehouse costs were $3 million and $2 million, respectively. Shipping cost per unit was calculated for each of the six regions served. Most of the warehouse was used for customized products. The existing ABC system provided an accurate cost per unit for the warehouse costs.

Sales and Marketing

Sales and marketing expenses were $28 million, of which $10 million consisted mostly of wages and commissions paid to salespeople, each responsible for a specific territory. Most of the remaining $18 million represent marketing expenses in the form of rebates for marketing efforts performed by the distributors, display units, local advertising, and for sponsorship of hunting, fishing, and rodeo events.

McCoy had considerable sales and marketing capabilities and significant historical data on their individual customers and the success of marketing and sales expenditures. As part of McCoy's ABC system, they also calculated and reported the profitability of each of their 2,500 customers. This information and data played an important part in identifying the response curves used in the optimization model.

CASE STUDY MODEL DATA

As is true of any supply chain network design model, the POC model we built is a series of geographically located nodes connected by links arranged in a hierarchy, from procurement to customer. The nodes contain facilities, and within the facilities, activities and products. These nodes and links are appropriately constrained (e.g., capacities).

However, the flows within the network (e.g., across a node, within a facility, or through an activity) are not known, because they are the answer to the question: "What is the optimal supply chain configuration to make, fulfill, and service the forecast?" Thus, the *essential* requirement for optimized planning is an understanding of unit costs and how they vary with volume. As will be described below, these relationships are referred to as cost function curves.

While there are a variety of input data elements, the three key ones for the McCoy case study model included cost function curves, response functions, and capacity constraints.

Cost Function Curves

Cost function curves are explicitly available from an ABC model. All the network costs in an EMP model must be represented as cost functions. Cost functions (as described by Dr. Charles Horngren, coauthor of the textbook *Cost Accounting, 12th Edition* [Prentice-Hall, 2006, page 333]) are "*descriptions of how a cost changes with changes in the level of an activity or volume relating to that cost.*"

Cost functions describe, mathematically, the relationship

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between volume changes (units, weight, or volume) and the cost changes driven by the volume changes. These costs can vary with volume in a variety of ways, including linearly variable with increases or decreases in volume, fixed costs that don't change with volume, or any combination of fixed and linear.

Cost functions must be a combination of fixed or linearly variable volumes, given the mathematical programming technique employed (MILP, as previously described). Thus, plotting the cost function with changes in cost on the *y* axis (the dependent variable) and changes in units of volume on the *x* axis (the independent variable) yields the following arithmetic relationship: cost = slope × units. The slope is expressed as cost/unit and is the key mathematical factor in the cost functions.

Thus, as described above, the two very different analytic techniques (ABC and supply chain network design) have exactly the same "key mathematical factors." This, in a nutshell, is why supply chain–based POC models can be easily created from ABC model data.

Thus, activity consumption rate (ACR = activity/product) and resource consumption rate (RCR = resource/activity) and the associated cost factor (CF = $/resource), when multiplied were, in fact, precisely the slope of the variable cost functions required in the POC model. Thus, slope = activity/unit of product × resource/activity × $/resource = $/unit of product = slope of cost function curve.

As described above, these costs can vary with volume in a variety of ways:

- Linearly variable with increases or decreases in volume.
- Fixed costs that don't change with volume at all.
- Stepwise fixed.

Exhibit 2

McCoy Financial Results for Base Year ($ Millions)

Total Sales	$135.3
Expenses	
Cost of Goods Sold	78.8
Shipping/Warehouse	5.0
Sales & Marketing	28.0
G&A	10.0
Total Expenses	121.8
Operating Income	$13.5

Response Functions

Response functions have been around for decades and link sales or marketing activities to revenue results. Specifically, they relax the assumption of a fixed forecast by predicting revenues at different levels of sales or marketing effort. Sales response functions are used to drive sales force resource optimization (SRO) while marketing response functions are used in marketing mix modeling.

These relationships are used to inform critical resource allocation decisions including how big the sales or marketing budget should be, and to which products and/or customers should these resources be allocated. As a result, this process can lead to changes in individual product or customer expenditures. In these approaches, the objective is to maximize the contribution of the sales and marketing efforts after accounting for the costs of these promotions and a fixed product margin.

There are a broad range of methods that can be used to estimate enterprise response functions, which differ in the time/effort involved and the precision that can be achieved. A partial list of these methods includes:

- In-market tests to isolate the impact of individual promotions.
- Econometric methods that rely on statistical analysis to estimate the sales impact of prior sales and marketing activities.
- Expert sessions that provide a structured process to solicit and refine estimates of the impact that a promotion will have.

Regardless of how the response functions are derived, they can be compared to actual results and recalibrated

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as needed. This is analogous to the financial variance analysis process. They are the reverse of cost functions because the independent variable is not units but rather sales and marketing expenditures. The dependent variable is units. Units are also frequently multiplied by price-to-yield revenues as the dependent variable. This created the need for six response functions about which McCoy had some knowledge and experience.

A significant advantage for business-to-business firms (B2B) is that the requisite response functions can be structured either to reflect the inventory replenishment demand of its customer or the final customer demand of its customer's customers. Depending on the circumstances, this could be a significant planning advantage for the B2B firm.

Capacity and Other Constraints

All constraints, including capacities, must be identified, as they are an explicit requirement for optimization. Further, while some constraints cannot be relaxed (e.g., facility size), others can. These relaxations are included in the model. Examples include:

- Limits on procurement availability
- Manufacturing capacity
- Distribution Center throughput, storage
- Energy consumption
- Carbon emissions
- Targets for inventory and customer service
- Transportation link restrictions
- Supply/demand imbalances (e.g., inventory build-ahead vs. overtime)
- Limits on sales and marketing expeditures

When appropriate, capacity relief was included in the model. Most of the activities' capacities were relieved with labor in the form of new hires and temporary workers. Two, however, required additional capital equipment.

CONCLUSIONS

EMP's functionality truly represents next-generation ABC based planning, both financially and operationally. It is, in effect, an optimization of the closed loop model CAM-I advanced in its 2004 book by that name.

Further, it is not "new" or "untested" analytics. Rather, it is simply the integration of two different and robust sets of analytics (i.e., MILP and predictive analytics) that have been commercially successful for decades.

For firms whose experience is with ABC modeling, the EMP POC model is a platform from which those firms can extend their operational uses of the ABC data from efforts focused on process improvements and customer/product profitability to annual financial and operational planning applications like forecasting and planning. With ABC data, an EMP POC model can be built with relatively little additional data gathering, as described above, reducing the model-build investment significantly.

No time need be spent at all descriptively, evaluating alternative solutions via scenario analysis. EMP uses prescriptive techniques that guarantee that the solution is the very best one possible (i.e., optimal). It answers the question: "What is the best *X?*" rather than the descriptive technique, which answers the question: "What will happen if *X* is done?" Thus, the future of financial and operational planning is about solving for the best *X* by looking at *every single combination* of sales, costs, constraints (e.g., capacity), and sales and marketing spending that result in the maximum profit, sales and marketing ROI, and optimally feasible supply chain.

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NOTE

1. See http://www.cam-i.org/wiki/index.php//mCL_TableOfContents

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