The Use of System Dynamics as a Cost Management Tool

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ABSTRACT

In today’s business world whose characteristics include limited financial resources it is critical to identify and monitor where and how these resources need to be invested in the company. The Master Budget represents a plan of action which specifies how financial resources will be acquired and invested during a particular time period. Activity-Based Budgeting (ABB) is a budgeting approach that integrates Activity-Based Costing (ABC) into the budgeting process. ABB’s approach forecasts the products to be produced and the customers to be served in order to determine the activities, which will be required, and therefore, identify the required resources. ABB leads to a better control of the firm’s indirect costs. Systems Dynamics represents a simulation approach with the ability to provide decisions based on the feedback that it receives from the process. SD analyzes the system status changes that correspond to the system variables’ changes and/or the interactions amongst them. This research presents an innovative preliminary application of System Dynamics as a Cost Management model based on the detailed cost information provided by ABC. The model can analyze and foresee the effect of each decision or policy implemented on the firm’s budget and financial performance.

Keywords: System Dynamics, Cost Management, Activity-Based Costing, Cash Flow Analysis

1. INTRODUCTION

Activity-Based Costing (ABC) is an accounting system which represents a different perspective to assign, instead of allocating; Manufacturing Overhead (MOH) costs. MOH costs are assigned to the cost objects by estimating the cost object activities consumption.

Johnson and Kaplan (1987) state that using Traditional Cost Allocation (TCA) systems decrease the accuracy of product costing, especially when accountants focus on the allocation of MOH costs to estimate the value of inventories [3]. Cooper and Kaplan introduced ABC costing in the late 1980s as a means to minimize this cost allocation deficiency. ABC costing can significantly decrease the cost allocation effect, but it does not completely eliminate it. In the mid 90s the use of ABC costing led to the management of the activities required in the products manufacturing processes; thus, Activity-Based Management (ABM). ABM is particularly effective in determining products and customers profitability.

According to ABM philosophy, ABC has been viewed as an indispensable step to implement other operational improvement approaches such as Just-in-Time (JIT), Business Process Reengineering (BPR), and Total Quality Management (TQM). Even though ABC implementation as cost accounting system is expensive and complicated, its managerial benefits and its impact on financial success are
the main reasons for its popularity.

Cooper [6] addresses the issue of the supporting role of ABC in the transition of a company to a lean enterprise. He identifies a lean enterprise as the one that has specific characteristics such as the adoption of JIT production system, the implementation of TQM, team-based work environment, supportive supplier relations, and high customer satisfaction. Similarly, Novićević and Antić [10] discuss ABC as an ‘enabler’ to sustain improvement initiatives (e.g. JIT, TQM), which optimize their effectiveness. Furthermore, some studies evaluate the ABC constructive role on a firm’s financial indicators such as Return on Investment (ROI) and Return on Assets (ROA); for example, [4] and [5].

The information provided by ABC costing can also be used for budgetary purposes. Activity-Based Budgeting (ABB) incorporates the information from ABC costing in order to determine financial objectives and to monitor the daily operations of a company. It also provides information on the results derived from improvement projects. ABB links the resource consumption with the actual activity consumption because it uses the information from ABC. Thus, ABB provides a better evaluation of the system efficiency as compared to the conventional budget system [2]. In order to increase business efficiency, we need to control the costs. There is a significant difference between cost reduction and cost control; companies can reduce their costs without necessarily controlling them. Cost control normally requires an intelligent and systematic cost reduction approach such as Lean Manufacturing (LM).

This study presents a preliminary research in the interdisciplinary area of Managerial Accounting and Operations Management. It applies System Dynamics (SD) to present a novel simulation-based cost management model. The reliability of the model is also enhanced by integrating the detailed cost information from ABC costing. The remainder of this article is organized as follows: section 2 elucidates the applied modeling approach and the relevant literature. Section 3 presents the preliminary SD cost monitoring model. The relevant summary and conclusion are discussed in the last section.

2. MODELING APPROACH

The modeling approach used in this study is System Dynamics. SD is a simulation approach with the ability to continuously update the system status through feedback loops. In SD simulation, each run will be based on the updated variables from the previous run. The two main reasons for SD’s popularity are the ability to model complex problems and the possibility of integrating qualitative factors e.g. human factors into the model.

Forrester [7] originally defines SD as “the study of the information feedback characteristics of industrial activity to show how organizational structure, amplification (in policies), and time delays (in decision and actions) interact to influence the success of the enterprise. It treats the interactions between the flows of information, money, orders, materials, personnel, and capital equipment in a company, an industry, or a national economy.”

According to [12], there are differences between Discrete Event Simulation (DES) models and SD models. In DES models, specific entities can be followed throughout the system, system state changes occur at discrete points of time. DES models are stochastic in nature; their structure consists of a network of queues and activities. DES models are actually applied for tactical level situations. On the other hand, in SD models specific entities cannot be followed throughout the system, system state and variables can change continuously at small segments of time. Stochastic features are rarely used in the SD models; the structure of SD models consists of a system of stocks and flows. SD models are mostly applied for strategic level situations.

The SD simulation approach has normally been utilized at the strategic level in service and Resource Management situations. Few studies have used SD as a cost analysis and cost management tool. Abdel Hamid and Madnick [1] used SD to evaluate the consequences of
multi-variables changes on the software development process costs, considering some managerial qualitative functions, e.g., planning, staffing, and controlling. SD has also been used to analyze and measure the importance of quality cost factors, e.g., preventive costs and external/internal failure costs in [8].

Macedo et al. [9] developed an ABC-based cost management model for the reengineering process of manufacturing a laboratory product. The model does not contain any feedback loops and works as a preliminary real-time cost calculator rather than as a cost management tool. A novel SD cost management model presented in this study contains feedback loops. The feedback loops shifted the budgeting and cost allocations process from a static process to a more dynamic process.

3. PRELIMINARY MODEL

According to Sterman [11], the Causal Loop Diagram (CLD) should be developed as the first step in SD modeling. CLD can facilitate the modeling process by indentifying the main variables and feedback loops. “A CLD consists of variables by arrows denoting the causal influences among the variables [11].” At this stage of modeling, it is not necessary to define the type of variables, e.g., auxiliary, stuck, and flow. The developed CLD has been created in four different parts. The positive and negative signs are defining the effect that the linked variables have on each other.

The first part of the CLD, Figure 1, shows how the manufacturing costs -including direct labor, direct material and relevant MOH- are estimated based on the production demand and production rate. The main feedback loops are: product (i) production rate → product (i) direct labor hour → product (i) direct labor cost → product (i) cost of goods manufactured → product (i) cost of goods sold → product (i) selling price → product (i) demand → product (i) production rate. Similar loops can be established for each product’s direct material costs and MOH costs. The other main loops are defined according to the inventory level and inventory value; product (i) production rate → product (i) inventory level → product (i) inventory value → product (i) cost of goods sold → product (i) selling price → product (i) demand → product (i) production rate.

The second part of CLD, Figure 2, shows how MOH costs are estimated based on ABC. The CLD only shows the batch-level MOH cost estimation. The model can update the activity pool rates in each run, based on the actual activity consumption and costs from the previous runs. The activity consumption is a function of the production rate. The activity cost is a function of the activity consumption and activity pool rates. Accordingly, the feedback loops of Batch-level activity pool rate → product (i) batch-level activity pool rate → product (i) total cost of batch-level activity → total cost of batch-level activity → batch-level activity pool rate for batch-level costs are defined. The similar approach can be applied to the other MOH costs.

The third part of CLD, Figure 3, shows how the manufacturing costs calculated in the previous stage are incorporated into the budget. The arrow crossed by a vertical line indicates a delay in the process. For example, receiving money after selling the item normally incorporates some unwilling delays which have an effect on the company’s account receivables and cash availability. The variables estimated in this part of the model will be used later to calculate the financial indicators.

The fourth part of CLD includes the financial indicators calculations. Figure 4, shows five financial indicators that the model can estimate. The current structure can estimate Gross Profit Margin and Net Profit Margin amongst the Profitability Financial Indicators. From the Liquidity Financial Indicators, the model can estimate Current Ratio, Inventory Turn Over, and Collection Period. More financial indicators such as, Working Capital, Days to Sell Inventory, and Account Payable Turn Over can also be incorporated to the current model structure.
4. CONCLUSION

The presented preliminary SD cost management modeling approach elaborates a new application of SD as a simulation technique. The SD feedback loops help the model to update the variables. The cost management model can link the activity resource consumption to the company’s budget by using ABC. It can also monitor and analyze the flow of costs and update the company’s budget and financial indicators continuously. The model assists management to foresee the effect of each decision taken on the company’s budget and financial performance.

In order to show the advantages of the model and as a future work, the model will be applied to an ABB case study. Moreover, financial indicators will be added to the model structure. For example, by incorporating the shareholders’ equity relevant variables, it will be possible to add Solvency Financial Indicators such as Financial Leverage Index and Financial Leverage Ratio into the model.

Another future work is to validate the cost management model output by using the Monte-Carlo simulation approach. In this case the model will be applied to a different combination of products and the profitability will be measured after a desirable period of time. By changing the products’ price elasticity randomly, different product combinations could be generated and applied to the model. In addition, a random number will be used to represent the delay between the time cash is received from the customers and the time it’s incorporated in the accounts receivable. This characteristic is useful to analyze the average cash availability of the company.

5. REFERENCES

Figure 1 - Manufacturing Costs Estimation

Figure 2 - Pool Rates Adjustment
Figure 3 – Budget Adjustment

Figure 4 - Financial Indicators Estimation