Measuring Business Process Quality Using Simulation

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1. Introduction

In the last decade, businesses endeavor to improve efficiencies, reduce costs, and enhance the quality of their products and processes. Such endeavors include Just-in-time, business process reengineering, time-based competitive strategy, quick response, ISO 9000 and benchmarking [4,5,14]. Many service oriented organizations are interested in adopting the quality system that meets ISO9000 standard to reduce the costs associated with poor quality, to become more competitive, or to meet customer expectation [2,7]. Despite their interests, the adoption of a quality system by the paperwork-oriented service process is relatively limited compared to the product-oriented process. The reason is that quality of the product is more visible than the quality of the service. With the lack of the visibility, it is difficult to convince the corporate sponsors to fund the process improvement project.

Simulation provides effective means to demonstrate the quality of the current process as well as quality improvement by the proposed new process. Simulation is not widely used in Korean firms as a means for business process improvement [13]. Some speculate that Korean business consultants are more comfortable with the qualitative tool rather than the quantitative analysis tool. The primary objective of this paper is to enhance our understanding of simulation to measure the quality of the organizational process. Simulation is an effective mechanism to provide insight into what could happen to the quality of organizational process that normally being taken granted [6].

In this paper, a multi-functional budgeting process, consisting of sales, production, purchasing and budget departments, is chosen as the domain of the organizational process scenario for describing the quality problems. In this scenarios, functional tasks related to the budget process lack coordination, generating the number of errors. Specifically, PC-based decision modeling activities related to the budget tasks are not coordinated, generating errors into the budget process. The generated errors do not remain dormant. They are propagated to the next step of the process, contaminating the rest of the process. This results in erroneous process outcome. Simulation model involving this scenario is developed to assess quality of the budget process. This error propagation can be shown effectively using simulation.

2. Type of Interdependencies and Associated Problems

Coordination is defined as the act of managing interdependencies between activities to achieve a goal [10]. Interdependencies exist whenever the output(s) of one decision model are the input(s) of one or more other models. Interdependencies also exist when several functional units are using models for essentially the same purpose; such models would have essentially the same inputs and outputs. Coordination problems in organizational modeling activities occur when the interdependencies between individual modeling activities are not well managed. In total, there are three types of interdependencies among individual modeling activities: common-model, prerequisite, and concurrent.

Common-Model Interdependence Under common-model interdependence, decision units develop their own models without interaction with other units; yet they ultimately create the same or similar models.

In the budget process example, common-model interdependence is found among the operating budget models of the functional units. Every functional-unit operating budget model has generic budget items like salaries, benefits, and supplies; and generic procedures to calculate those items. Without coordination of common-model interdependency, different budget models, yet with the same purpose, are generated by the functional units, introducing inconsistencies among the models. The causes of inconsistency are: assumption differences; differences involving data such as scale, type, name differences and missing, conflicting values; as well as procedure (business rule) differences. The conflicts among the redundant models produce inconsistent results relative to the budget process.

Prerequisite Interdependence A prerequisite interdependence creates a temporal relationship among functional units. The modeling task of an individual functional unit depends on the output data that are available from the models of remote functional units. This occurs when results achieved by a decision model influence or constrain other decision models. Each unit may be maintaining common-model interdependence as well.

In the budget process, a prerequisite interdependency is found between the sales and production budget models -- the production budget model uses *unit_sales* data from the sales budget model to determine *unit_cost_of_goods_sold*. Without electronic coordination, *unit_sales* forecasted by the previous functional model -- the sales budget model, is delivered to the subsequent functional model -- the production model, by memo or report. Upon receiving the report from the sales department, the production department enters the received information into the production budget model. Retyping data due to lack of electronic integration may generate errors that affect quality of the process outcomes.

The data errors that occurred during retyping may introduce additional errors when the outputs of the model are passed on to the next phase of the process. Once these errors are passed into the next phase, they are more likely to be undetected [3, 11]. The undetected errors do not remain dormant until detected. They lead an active existence, introducing still more errors into the process. The escalation in the number of active errors in the model comes in two ways. The first is through the multiplier to active error generation due to multiple outputs emanating from a single error source [1]. This multiplier represents the number of new errors that a single active error reproduces in one generation. The second is through feeding on itself. The earlier the undetected error occurs, the more generations of errors it will produce, and thus the more costly it will end up being.

Concurrent Interdependence Concurrent interdependence exists when there is a feedback cycle or loop involving two or more models. It requires that more than one functional unit model be involved in the model execution at the same time. Real-time information sharing is required regarding the effect of alternative strategies on each functional unit. Each unit may have common-model and prerequisite interdependencies as well.

The following illustrates how the companies are evaluating their planning strategies when concurrent interdependencies across functional models are not recognized, and not coordinated. An additional model called a corporate planning model is used to investigate the consequences of alternative planning strategies on functional- and corporate-level performances. Substantial sensitivity analyses are conducted by use of the model. The planning model is comprised of several segments, each of which represents the activities of a functional unit and collectively represent a series of interrelated flows of materials, information, and decisions among functional blocks of activities in the firm. An exemplar planning model is presented in Appendix A for the purpose of sensitivity studies. One usage of the planning model is as follows: when the aggregated budget figures do not produce a satisfactory *gross margin*, the company would lower the *unit_price* assumption and run the planning model to see the impact on *gross margin*. The increased *unit_sales* (i.e., sales volume) and *sales_revenue* (i.e. the outputs of the sales segment) due to the price reduction, would affect the output of the production segment, *unit_cost_of_goods_sold* and the output of the income statement segment, *gross margin*.

Any corporate planning model is an approximate representation of interrelationships between functional units [12]. The approximation may provide insufficient accuracy or erroneous results for certain input variables [8]. However, due to economic and time constraints, it may not be possible for the corporate budget department (i.e., the department in charge of the corporate-level budget planning) to build a planning model that specifies each assumption, constant, variable, or parameter used by the functional units. Therefore, the quality of the organizational plan has to be traded with the costs of gathering or estimating the data [8].

Concurrent executions of the already existing functional models--the sales, production, and corporate budget models -- could provide the means to experiment with alternative planning strategies utilizing assumptions and parameters defined by owner functional units. Therefore, by taking advantage of user-developed models, the company could produce an organizational plan of a better quality.

3. Simulation Models

The simulation models developed for this study are stochastic processes in which extensive use of literature findings are utilized in the parameterization of the models. The models simulate a budget process involving interdependencies among various budgeting models. The models include simulation of model formulation, and model execution phases of budgeting processes for all involved functional units. All types of interdependencies are existent within the models. One replication of each model involves the execution of the budgeting process for all departments involved.

Selected from the accounting literature [9], the budget process used in the simulations is representative of manufacturing companies. It consists of the eight functional units: sales, production purchasing, budget, and the four administrative offices -- office of president, office of treasurer, office of public relations, and office of management services.

Figure 1 depicts the logical flow for the simulation model of the total budget process without any coordination. Capitalized verbs that correspond with user-defined GPSS block names have the following meanings. The WRITE block simulates the creation of a memo containing data that must be transmitted to other departments. The DEVELOP block simulates the formulation of a model. Specifically, the DEVELOP block describes model development activity that comprises planning, creating, and quality assurance phases. The ENTER block simulates the entering of data to parameterize a model. Data delivered in the form of memos are followed by manual re-keying once they reach their destination department. The ANALYZE block represents sensitivity analyses performed to adjust functional budget figures at the organizational level.

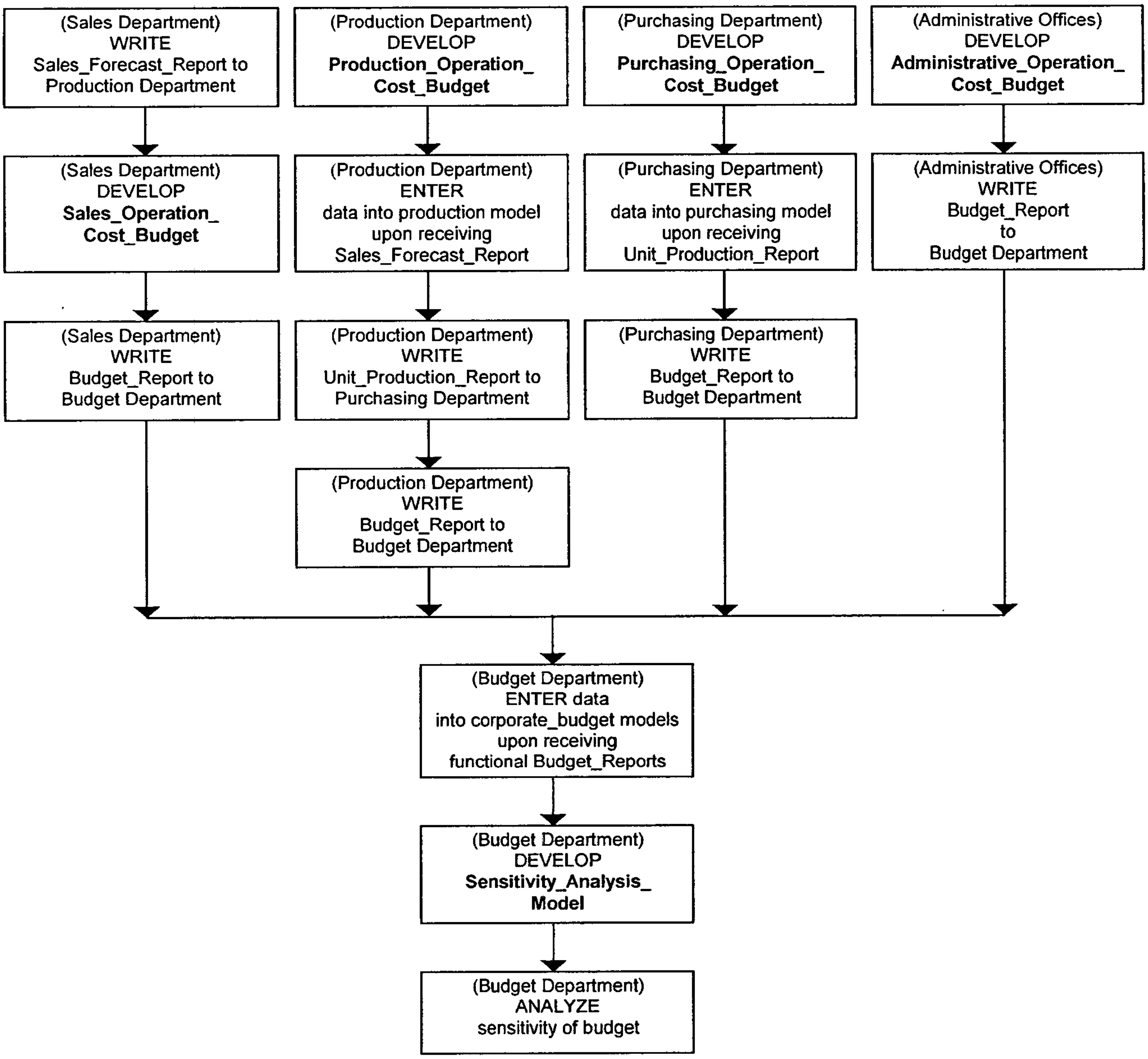

Figure 1. Simulation Model for the Budget Process without any Coordination

WRITE: creation and delivery of a memo for data transmission.

DEVELOP: model formulation.

ENTER: manual re-keying of data.

ANALYZE: sensitivity analyses to adjust functional budget figures.

The boxes DEVELOP and ENTER, in the flowchart, represent error prone activities. The errors generated during these activities are propagated to subsequent functional units through the prerequisite interdependency. Sensitivity analyses help users recognize opportunities or avoid pitfalls depicted in the decision models they created. The errors generated during DEVELOP and ENTER activities, are assumed to have a probability of being detected during the ANALYZE activity and corrected. The total number of errors generated from the simulation model in Figure 1 depends on (1) the error generation rate during DEVELOP and ENTER activities, (2) the error detection rate during ANALYZE activities, (3) the error correction rate during the rework, (4) the size of the models developed during the DEVELOP activity and (5) the number of data items entered during the ENTER activity. A probability function for each rate, such as a probability function for each entered data item being incorrect, is derived from the relevant literature. Each rate is summarized in Table1. The size of the budget models and the number of input data are randomized by the number of budget periods that each budget model prepares. The budget periods randomized range from 3 (the quarterly budget with monthly budget periods) to 12 (the annual budget with monthly budget periods).

Table 1: Parameter Values Used in the Simulation [6]

INTERDEPENDENCY TYPE	NO COORDINATION
Common model	Error Generation Rate due to Inconsistency: 1) 5.1 percent (uniform distribution) for an original formula. 2) 2.2 percent (uniform distribution) for a copied formula.
Prerequisite	1. Undetected Typing Error Rate: 4.6 percent (uniform distribution). 2. Error Propagation Rate is determined by Internal and external multiplier for error generation.
Concurrent	1. Error Generation Rate due to Approximation: 1) 5.1 percent (uniform distribution) for an original formula. 2) 2.2 percent (uniform distribution) for a copied formula. 2. Probability of error detection during sensitivity analyses: 0.5.

4. Conclusion

Since the quality of the service is less visible than the quality of the product, the adoption of a quality system by the paperwork-oriented service process is relatively limited. With the lack of the visibility, it is difficult to convince the corporate sponsors to fund the process improvement project.

According to this study, the number of errors generated during the budget process was 18.13 with a standard deviation 10.10. The potential costs emanating from the poor decision quality that is precipitant from the erroneous models can be catastrophic. Especially when concerned with issues involving the organizational budget, it becomes important to minimize the possibility of error introduction through improvements to the model creation and maintenance process.

Simulation provides effective means to demonstrate the quality of the current process as well as quality improvement by the proposed new process. The focus on quality enhances the productivity of the process as well. By building models right the first time (or reusing standardized ones), the cycle times (the time to formulate, construct and test the model) and costs associated with distributed decision support modeling can be reduced as well. Detecting and correcting errors in subsequent components of the distributed model are both costly and time consuming since all the previous components that were contaminated due to errors have to be reworked.

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