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PREDICTING AND IMPROVING COMPLEX BUSINESS PROCESSES: VALUES AND LIMITATIONS OF MODELING AND SIMULATION TECHNOLOGIES

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ABSTRACT

This paper argues that the value of simulation and modeling technology tends to be contingent on creating models that can offer a systematic and well defined way of representing firm's structure and business processes. Over time, stable and simple business processes can reach equilibrium. As such, the behavior of the stable systems can be predicted through modeling and simulation. However, complexity in hierarchical business processes and introduction of random changes within such business processes create dynamic systems that have a tendency not to reach equilibrium. Hence, simulation and modeling may add less value in predictability of behavior within complex and dynamic business processes.

1 INTRODUCTION

Global competition has pressured structurally complex corporations to technologically and strategically adapt to radically changing market conditions (Bartlett, Ghoshal, and Birkinshaw 2004). In order to achieve strategic co-alignment within increasingly complex and dynamic industry environment, corporations are required to develop core competencies in data-based evaluation and simulation of existing business process performance. The application of information (Modarres and Bahrami 1997) and simulation (Nylor, Balinfy, Burdick, and Chu 1966; Profozich 1998) technologies enhance corporations' capabilities to achieve in-depth understanding of internal process performance, and correct allocation of resources. Moreover, systematic data collection, dynamic modeling and simulation of business processes enables top management to examine potential scenarios such as simulation scenarios in radical reengineering of business processes, prediction of the outcome of reengineering strategies prior to the implementation, and the analyses of process reengineering at macro and sub-process levels and their effects on the cross-functional processes.

For the past decade increased expectations for higher performance within domestic and global markets (Hammer and Champy 1993) have pressured a great number of corporations to undertake numerous improvement strategies through reengineering business processes, downsizing (McKinley 1993), total quality programs, and innovation (Mone, McKinley, and Baker 1988). According to Hammer and Champy (1993), pressures for higher performance tend to create crises. Corporation's response to such performance crises tend to be through strategic change, administrative reorganization (Modarres 1998) and reengineering of business processes. More recently, a number of researchers have posited that reengineering strategies enhance industrial firms' capabilities in reducing operation costs, cycle times and produce high quality products and services (Roberts 1996; Hammer and Champy 1995). Moreover, business process reengineering is of significant benefit to strategic leaders in creating value for customers (Hitt, Ireland, and Hosskisson 2005). A number of elements such as structural arrangements and lack of appropriate technologies enhance the risk of failure of reengineering strategies. Past researchers have argued that the risk of failure in reengineering efforts to increases due to lack of leadership commitment, resistance to change and lack of administrative skill in managing change processes (Hammer and Staton 1994). The risk of failure may also be positively influence by lack of proper information technology, poor communication mechanism, proper diagnosis of process performance, particularly within complex and hierarchical business processes.

Contrasting views, on the effects of radical reengineering on corporate performance, and the degree to which corporations should allocate resources on analysis of existing processes have led to two polemic streams of research shaped by researchers. A number of authors have argued that radical reengineering of complex processes tend to be contingent on availability of valued resources, managerial capability in fundamentally rethink and redesign business processes (Hammer and Champy 1993), leadership commitment to change (Hammer and Stanton

1994), and changes in existing corporate culture (Roberts 1994). This body of knowledge has focused on the effects of process reengineering on corporations' performance. In this view, reengineering enhances the overall corporate performance and facilitates a systematic review and redesign of critical business processes (Wright and Noe 1996). Moreover, radical reengineering of business processes improves process efficiency and identifies and redesigns activities that cross functional lines (Render and Heizer 1997).

Shifting the perspective and representing merely another side of a complex relationship, researchers have centered attention on the magnitude of change and negative effects of process complexity on corporations' performance. In this view, detail analysis such as systematic data collection and in-depth knowledge of existing process (e.g., cost and performance) tends to be a wasteful activity, misallocation of resources (Hammer and Stanton 1994), and increase the risk of failure. Moreover, understanding the actual performance of existing capabilities, objective analysis of process performance and complexity of cross-functional processes creates great difficulty in true assessment of current capabilities (Roberts 1996). The above research indicates that reengineering tend to increase the probability of failure, and has a negative impact on internal performance and external customers. Although this body of work acknowledges the importance of information technologies, it does not, however, recognize the values of process modeling and simulation and decision support systems (information technologies) detail analysis of existing processes and how such technologies can enhance corporations' capabilities in implementing reengineering strategies.

While researchers have made significant advances in identifying factors that contribute to success and failure of reengineering, several important issues remain largely unexplored. First, researchers have not considered the effects of process complexity on implementation of reengineering strategies. Complex processes tend to be hierarchical cross-functional. Another serious omission in the past research centers on the effects of information, simulation and modeling technologies in capturing essential elements and causal relations to predict the behavior of the complex and hierarchical business processes prior to the implementation of reengineering strategies. Moreover, previous researchers have not addressed how such technologies can enhance industrial firms' capabilities in implementing radical or evolutionary reengineering strategies. Complexity (hierarchical processes) and random changes within complex processes tend to create dynamic systems that have a tendency not to reach equilibrium. Hence, the values of simulation and modeling of complex and dynamic systems in predictability of such systems are unclear. The present research seeks to explore whether process complexity and variability influence the implementation of reengineering strategies. Moreover, this research develops theoretical arguments on the values and limitations of simulation and modeling technologies in measuring process performance and implementation of reengineering strategies. The present research is organized in the following order. The introduction provides a review of relevant literature on complexity and hierarchy within business processes. The issues concerning reengineering business processes and effects of complexity on reengineering process are discussed in section 2. Section 3 focuses on the value and limitations of modeling and simulation technologies and in reengineering business processes. Section 4 describes the future research and concluding remarks.

2 THEORETICAL BACKGROUND

2.1 Effects of Complexity on Business Process Improvements

Business process is creation of value to internal and external customers through collection of tasks and activities that takes one or multiple inputs and creates a single /multiple outputs. Business process is an important variable in understanding the nature and interrelation among activities within complex corporations. Davenport and Short (1990) defined business process as a set of causal and logical interrelated tasks performed to achieve a determined outcome. According to Davenport (1993), processes can also be defined as a set of activities that are structured (e.g., cross functionally, or hierarchically within a particular function) and measured produce a specified output for both internal and external customers. Within corporations with complex structures, business processes tend to be inter-connected with other internal processes. As such, adjacent cross-functional sub-units tend to use the process outputs as their input.

Structurally complex corporations support and maintain greater numbers interrelated and hierarchical processes. Large corporations contain complex and cross functional business processes that are divided into autonomous, semi-autonomous, sequential, or concurrent sub-processes. According to Simon (1982), complex systems are composed of interrelated sub-systems, each of the latter [sub-systems] being in turn hierarchic in structure until the lowest level of elementary sub-system is reached. Within the complex hierarchical processes, the sub-processes are subordinated by a functional relation to the macro business process they belong to. As such, complex hierarchical processes are analyzable into successive sets of sub-processes and introduction of radical reengineering affects both macro processes and their subordinated sub-processes. The sub-processes within hierarchical systems are nested within macro processes. As such, variations and changes resulted from sub-system interactions will be manifest at the macro level processes. Hence, higher vertical process decomposability tends to lead to higher levels of process complexity. Moreover, within a dynamic system variability of the macro processes tend to be influenced by interactions and changes of the sub-systems. The complexity of hierarchical processes, therefore, create great difficulty in fundamental redesign within such processes and predicting the outcome of drastic reengineering. Moreover, the dynamic interactions within micro sub-processes create a number of problems that may enhance the probability of failure. The complexity of hierarchical processes tends to reduce the possibility of identifying the risks attached to drastic reengineering. That is, the impact of change on other cross-functional processes, and the likelihood that a particular risk event will occur (Roberts 1994). Hierarchical processes also tend to have a negative influence on the selection of the right process to reform.

The center of the debate in reengineering process tends to be the reallocation of existing resources necessary for the documentation and detail analyses of the existing processes. Past researchers have indicated that extensive and detail analysis and documentation of existing business processes are misallocation of existing resources and irrelevant to reengineering initiative. According to Hammer and Stanton (1994), reengineering is initiated to correct for the performance shortcomings of the existing processes. As such, the underlying assumptions that shape the processes ought to be replaced by new assumption. The authors also remarked that teams chartered to analyze the performance adequacy of existing processes may engage in political activities and maintain the status quo and power bases, and resist reengineering. Moreover, reengineering, in this view, identifies and discards the element of process complexity and disposes of the complexity assumption.

Understanding the behavior of existing processes under various conditions, however, can be instrumental in gathering appropriate metrics and identifying duplication of activities, and the low performance processes. The causal connection within hierarchical processes and the assessment of the micro level variability and changes on macro processes tend to be essential in reengineering strategies. Complex processes tend to be sequential and interrelated. Such sequential and integrated business processes require greater degree of coordination for change and reengineering. Sequential business processes are complex and necessitates greater coordination and planning as the output of one process serves as an input for another. That is process "C" can be performed after successful completion of its preceding process "B" which in turn rests on process "A" and so on (e.g., Thompson 1967). Within such systems low process variations through repetition facilitate proportional allocation of the resources based on process capacity and construction of complex work flow arrangements. Similarly, integrated hierarchical processes tend to be complex. Dynamism and variations resulted from micro (sub-systems) interactions within integrated business processes create difficulty in implementing radical reengineering without increasing the risk of failure.

3 THE INFLUENCE OF MODELING AND SIMULATION TECHNOLOGIES ON PROCESS IMPROVEMENT STRATEGIES

In this section we describe whether static (process models) and dynamic (simulation) analyses enhance the industrial firms' capabilities in analyzing existing process performance and coordinating reengineering process. This section will also focus on the values and limitation of process models and simulation technology in reengineering complex hierarchical business processes.

3.1 Process Complexity and Static Analysis: Values and Limitations of Static Modeling

Understanding business processes is contingent on creating a methodology that enables us to analyze integrated processes. Both modeling and simulation technologies facilitate a greater learning about business process architecture and assess the behavior of business processes under various conditions. Process models facilitate a systematic approach to documenting, and representing the static structure of the business processes. Process models also enhance the knowledge base about the causal connections between the macro and micro (sub-processes). Industrial and service firms use process models as a means to identify the missing information links, rework cycles, strategic and tactical change and their impact on the current process performance. According to Busby and Williams (1993) argued that process models identify the structure of the current operations and provide valued information on instituting a self adjustment mechanism for process improvement. The authors also indicated that process models permit process owners and managers to identify inadequate connections between activities and information systems, duplications of activities, and creation of a macro model about cross functional interconnections. Similarly, Hammer and Champy (1993) indicated that success in process reengineering can be attributed to creation of the flow charts, spread sheets and process models. Hence, analyzing the static process models reveal information on the effectiveness and degree of certainty industrial and business firms operate.

Macro level process defines how customer requirements are defined, and design engineers create geometric drawings based on customer requirements and existing technology for manufacturing. The process illustrated here is a collection of both sequential and concurrent activities within various business units and cross-functions. The macro level process also establishes the fundamental facts about market (customer requirements) and internal requirements (technology and resources). As indicated earlier complex processes tend to be hierarchical, and can be viewed and analyzed at various levels of detail. That is, market requirement consist of industry analysis, competitive analysis, and latest technology. Defined processes and activities consist of basic requirements to identify whether current technology can facilitate manufacturability. Moreover, at micro (sub-process) level analysis of process model can reveal the strength and the weaknesses of the existing processes. The micro models are valuable to analysts in identifying critical information about the ordering of the activities within a process (sequential and concurrent activities), decision points, and missing elements such as self-check activities for process improvements, communication mechanisms among various teams, or the need for new information systems to improve the existing process.

The analysis of the static model tends to constrain the analysts to capture the real behavior of the system, and assess the influence of variability on system's performance. Profozich (1998) argued that static tools and models are incapable of dynamic analysis. As such the static tool may reflect an optimistic view of the system's performance. Profozich also indicated that increased variability within a system generates greater errors in static analysis. In order to capture the true system's behavior under various conditions, all the possible scenarios ought to be considered. That is, the effects of randomness and variability ought to be measured at macro and micro levels within hierarchy. Static process models and tools have great difficulty in assessing system's performance. The shortcomings of static models in conducting dynamic analysis can be categorized in the following ways. First, static models are not capable of considering variability and randomness and process capability to respond to change. The static process models do not provide sufficient information to identify detail deficiencies in the hierarchical processes and the costs involve in correcting such deficiencies. Second, static models are not capable of assessing the effects of variability and randomness at various levels of hierarchy. Moreover, such models are focused on each process as a separate and defined entity and can not assess the collateral impact of process change and reengineering on adjacent processes. Third, static process models lack the capability to assess the impact of process reengineering prior to implementation (proof of concept). Busby and Williams (1993) argued that the information offered by static process models may not be novel in nature. That is, static models provide a snapshot of the dynamic process and are unable to predict system's behavior. In predicting the system's behavior under various conditions it is necessary to able to introduce the variability in the environment and in each process. According to Profozich (1998) the assumption that each process will operate on the average is insufficient. In order to identify bottlenecks, trends, and resource allocations a dynamic analysis of business process performance is necessary.

3.2 Process Complexity and Dynamic Analysis: Values and Limitations of Simulation Technology

Simulation technology enables industrial firms to consider variability and randomness in their business processes. Consideration of the variability and randomness enhances firms' capabilities to capture the behavior of the processes under various conditions (e.g., various "what-if scenarios). Moreover, simulation technology can influence the nature of the decision made in a firms as well as the decision-making process. Historically, the process design and optimization has been accomplished through static modeling; simulation allows greater flexibility in model validation, change in a dynamic fashion. Such dynamic analysis provides an opportunity to test for unexpected interactions within the system or check the robustness of the design (Swain 1995). Simulation allows industrial firms to formulate their operational strategies based on process optimization. Swain (1995) remarked that simulation can be considered as a vital component in modeling the enterprise-wide modeling, in which processes once treated as separate functions (e.g., manufacturing, sales, design) can be modeled as a group and optimized as a system. Profozich (1998) argued that variability and "moving time clock" identify the process capability under various conditions. The author indicated that variability tend to have a ripple effect on the decision processes. The businesses tend to have greater numbers of conditional decision making and process interdependence that dramatically amplifies the effect of variability within the business processes. Moreover, Profozich (1998) argues that the combination of one moving time clock and dynamic decision making within the processes create a chaos environment that can negatively influence the performance significantly.

3.3 Effect of Randomness and Variability on Complex Processes

Typically randomness enters a simulation model in 3 ways: (1) in the modeling of interarrival times of new entities into the system, (2) in percentage routing of items to different processes or subprocesses, and (3) in modeling the flow times of individual process steps. A random variable such as a cycle time for a whole process or subprocess will be a combination of the random variables for the individual process steps. (This discussion will concentrate on process cycle time, although it is applicable to any outcome of a process that is the sum of outcomes of process steps.) These random variables combine through summation, extreme values, and mixture. Summation is, of course, the adding up of values of random variables from successive, sequential process steps. The cycle time of a simple sequential process will be the sum of the cycle times of each of the steps of that process.

An extreme value combination of random variables occurs when a an item enters a set of parallel processing steps but cannot continue until all of the processing steps are complete. For example a new customer request may be routed simultaneously to multiple Engineering departments for initial review before a response can be made.

Mixtures of distributions occur wherever a percentage routing or feedback loop exists. If a subprocess has a percentage of items passed on to the next process step and the remainder sent to rework, the cycle time for that subprocess will have a mixture of two distributions, that of the normally processed items and that of the reworked items. These three methods of combining random variables each produce different results. Summation tends (under rather broad conditions) to produce random variables that are approximately normal, even though the components of the sum may not be normally distributed. The cycle time of a sequential process that is the sum of many steps, each with a small contribution, would therefore be expected to be approximately normal with mean and variance equal to the sums of variances of the components.

Extreme value distributions, on the other hand, tend to be highly asymmetrical. If an extreme value distribution makes up a large portion of the distribution of a process cycle time, this will tend to make the process cycle time asymmetrical also. Mixture distributions are the least likely to resemble standard mathematical distributions and to exhibit such features as multimodality. Use of simulation to predict the range of possible values from such a distribution (as opposed to estimates of the mean) will require a large number of replications in order to form an empirical distribution function. A process may be complex in two ways: having a large number of steps or having a complex set of percentage routings and feedback loops. To the extent that complexity consists of a simply a large number of process steps, the process cycle time is likely to be approximately normal. The process should be predictable through simulation; however the ranges of prediction will depend on the overall process variance. On the other hand, a process with a complex network of feedback loops is likely to produce a complex distribution of overall cycle time. The distribution of such a process can be estimated by forming an empirical distribution function, but this will typically require a very large number of replications.

4 CONCLUSION

In this paper I discussed how process complexity and hierarchy influence the process reengineering strategies. It was argued that, under dynamic conditions, static modeling technologies are not capable of performing in-depth analysis and predicting the behavior of the system. Dynamic systems change frequently both at micro and macro levels. Static modeling technologies are not capable of assessing the need to make changes. Moreover, process variability reduces the usefulness of static models in assessing the impact of change on cross-functional processes and sub-processes (hierarchies). Simulation adds greater value to the understanding and reengineering the business processes. However, as the complexity, randomness and variability within business processes increases the predictability of process behavior under various conditions becomes more problematic. That is the range of predictions becomes too wide for a decision base. Future research should concentrate on empirical study to test the propositions developed in this paper. Moreover, future researchers should develop information systems that are designed to integrate several technologies. Such integrated technology will facilitate the creation of information repository integrated with simulation, modeling, and other databases.

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