The Nature and Role of Complexity in Simulation Performance: The Case of Multi-Stage New Product Screening

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ABSTRACT

The objective of this study is to understand the nature and role of complexity in simulation performance. In order to do this, a system dynamics model of the product development pipeline was developed, and an online game based on that model was created. An experiment was run where subject made a series of decisions on one or two variables for many periods, with different levels of information available to them (attribute complexity). Hypotheses were proposed based on the literature. The results confirmed the hypotheses relating degree of difficulty to distance from optimality. Two factors adversely affected the subjects' performance: dealing with more complex information on performance (more than one attribute) and having to make more than one simultaneous decision, i.e. more than one decision per period. The latter condition was more detrimental to performance than the former.

Keywords: Behavioral Study, Decision Biases, Product Development, Product Pipeline Management, Stage/Gate, System Dynamics

INTRODUCTION

It is clear to most companies that today’s new products will decide tomorrow’s company profile, as innovation is diffused (Bhushan, 2012, 2013). Therefore, we cannot underestimate the importance of improving product development performance in a competitive business environment (Wheelwright & Clark, 1992; Griffin, 1997; Cooper, 1998).

Many product development organizations put their new product development (NPD) projects through a series of screens (a.k.a. stages/gates) into order to release only the best performing projects into the market (Cooper et al., 1998). The term product pipeline management (PPM)
alludes to the practice of starting and steering several promising projects through this sequence of screens. For example, Girotra et al. (2005) documents development processes for pharmaceutical drugs that follow a number of well-defined stages/gates. In each stage, a team creates potential value by means of development tasks, gathers information to evaluate the technical adequacy of the project, and forecasts the future market performance of the end product. In each of the corresponding gates, managers examine projected technical and market performance and use that data to assign net present value (NPV) to the projects, and then determine whether to proceed or terminate a fraction of the projects based on a predetermined NPV threshold.

Literature treats the process of product pipeline management as a dynamic resource allocation problem with congestion effects due to resource constraints (Reinertsen, 1997; Griffin, 1997; Cusumano & Nobeoka, 1998; Ulrich & Eppinger, 2004). It is possible to explore decision rules for PPM from different viewpoints: cycle time implications (Adler et al., 1995); stagewise resource allocation (Banerjee & Hopp, 2001). More recently, a behavioral viewpoint generated resource allocation insights, in terms of heuristics for resource allocation across multiple stages of a pharmaceutical R&D process (Gino & Pisano, 2005a).

Product Pipeline management is a complex undertaking. Pharmaceutical and industrial companies invest large sums in NPD projects, managing portfolios that employ teams of hundreds or even thousands of employees. Managers in such companies have to make a series of decisions, both locally (at each stage) and globally; they constantly update these decisions, especially at the review points. A key global decision is the allocation of limited resources (workers) across stages. Since we assume that resources are limited, each stage must have a fraction of the total amount of available resources. If there is an increase in the fraction of resources at one stage, there must be a reduction in the fraction of resources at another stage. Local decisions include level of thresholds for minimum net present value (NPV) of projects, work intensity of the teams and task complexity.

Such a complex development process as PPM usually deals with standardized procedures, adoption of best practices, and the use of IS tools as facilitators. But even with such powerful tools at their disposal, we do not expect managers’ choices to be completely rational. We recognize that the mere possession of information systems and availability of data does not imply effective decision making and the use of these systems by managers (Bendoly, Donohue & Schultz, 2006; Loch & Wu, 2007). Decision biases and simplifying heuristics contribute to an increase in the distance between actual and optimal decisions.

The various methods and tools most commonly used for management training are insufficient for dealing with the complexity of organizational processes such as PPM. It seems clear that the system dynamics (SD) approach would allow the treatment of complexity in a more realistic way (Azar, 2012; Machuca, 2000).

In this article, we explore how managers’ performance can be affected by the complexity of the PPM problem. We define “complexity” in terms of both the number of simultaneous decisions (i.e., the manager makes more than one decision per period) and of the complexity of information (number of attributes) available to the manager. We also use the term “degree of difficulty” here to mean “complexity” in order to avoid confusion with the decision variable “task complexity.” The theoretical foundation for this research is behavioral literature on social psychology and operations management. This experimental study focuses on subjects’ performance in an SD managerial game simulating a product-development pipeline, which they played on line. The results confirmed the hypotheses relating degree of difficulty to distance from optimality. Two factors adversely affected the subjects’ performance: dealing with more complex information
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