

Chapter XXVI

Simulating Product Invention Using InventSim

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ABSTRACT

This chapter describes a novel simulation model (InventSim) of the process of product invention. Invention is conceptualized as a process of directed search on a landscape of product design possibilities, by a population of profit-seeking inventors. The simulator embeds a number of real-world search heuristics of inventors, including anchoring, election, thought experiments, fitness sharing, imitation, and trial and error. A series of simulation experiments are undertaken to examine the sensitivity of the populational rate of advance in product sophistication to changes in the choice of search heuristics employed by inventors. The key finding of the experiments is that if search heuristics are confined to those that are rooted in past experience, or to heuristics that merely generate variety, limited product advance occurs. Notable advance occurs only when inventors' expectations of the relative payoffs for potential product inventions are incorporated into the model of invention. The results demonstrate the importance of human direction and expectations in invention. They also support the importance of formal product/project evaluation procedures in organizations, and the importance of market information when inventing new products.

INTRODUCTION

The importance of invention and innovation as an engine for economic growth, and in shaping market structure, has long been recognized (Schumpeter, 1934, 1943; Nelson & Winter, 1982; Abernathy & Clark, 1985; Maskus & McDaniel, 1999). The invention of new products can enhance the efficiency with which inputs can be converted into outputs (for example, the invention of more efficient production equipment) or can lead to the qualitative transformation of the structure of the economy by creating completely new products (Freeman & Soete, 1997).

Given the economic and social importance of the development of new products, questions of interest naturally arise concerning the dynamics of the process of invention; these form the research domain of this chapter. This domain is distinguished from the study of the commercial implications of inventions once they are created. Fleming and Sorenson (2001) note that while the processes of commercial diffusion of new goods have attracted substantial study, “we lack a systematic and empirically validated theory of invention” (p. 1019).

The lack of a theory of invention leaves open the question: How do inventors actually invent? Given that no inventor can try all possible combinations of even the set of already discovered raw components when attempting to invent a novel product, two further questions arise: What methods do inventors employ to simplify their task? and What are the implications of these methods for the rate of inventive progress?

These apparently simple questions are highly significant. Without a robust theory of invention, managers’ ability to create organizations that encourage inventive practices is constrained, and policymakers risk making sub-optimal decisions regarding how best to en-

courage invention in society in order to promote long-term economic growth. This chapter focuses attention on the role of search heuristics in the decision-making processes of inventors.

The Inventor’s Problem

In many real-world decision scenarios, including product invention, inventors are faced with three key problems, a large decision space (many variables), interconnectedness of solution elements (a complex mapping between individual elements of a solution and the payoff to the whole solution), and difficulties in assessing the likely payoffs to inventive ideas *ex-ante* their physical implementation (see Figure 1).

In the case of product invention, a vast number of possible product designs exist, and inventors must decide which of these possibilities to pursue. Their decision as to where to concentrate their inventive efforts is driven by the *search heuristics* they use, and their expectations as to the profitability of potential products. These expectations are subject to error for two reasons, technical uncertainty as to how a large system of components (a product) will behave, and commercial uncertainty as to what return a product will earn if it is successfully created.

A search heuristic is defined as: *a method for searching for an acceptable solution to a problem without considering all possible solution alternatives*. This definition encompasses a broad range of structures, for example an organizational structure can be considered as a search heuristic (Cohen, 1981). Search heuristics are widely used in everyday decision making, either because of the impossibility of determining and evaluating all possible solutions to a problem, or because the benefits from obtaining the best, rather than a good solution to a problem are outweighed by the extra costs of obtaining the optimal solution. Search heuris-

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