

Developments in Business Simulation and Experiential Learning, Volume 29, 2002
**THE IMPACT OF PUBLIC POLICY ON INNOVATION: A
SIMULATION PROJECT FOR RESEARCH AND TEACHING**

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ABSTRACT

This project represents the co-development of a research and teaching simulation software system. The theoretical model is introduced and developed to answer research questions important to the scholarly pursuits of the author while at the same time the conversion of scholarly work into a viable teaching and learning platform is explored. This project unpacks the factors that affect government policies that attempt to encourage innovation through collaboration among industry participants. By understanding more about the impact of industry and environmental factors both government and industry members can better understand the most beneficial industrial collaboration policies to pursue.

This project represents the co-development of a research and teaching simulation software system based upon a National Science Foundation grant proposal. The theoretical model is introduced and developed to answer research questions important to the scholarly pursuits of the author while at the same time the conversion of scholarly work into a viable teaching and learning platform is explored.

The research plan addresses questions that unpack the effects of environmental factors (e.g., public policies, economic factors, industry-level associations or groups), and the effects of firm level strategies and decision-making on the level of information technology innovation within a population of organizations. The theoretical foundation for this research is based on the integration of the organizational learning perspective and the evolutionary approach to economic change. The research methods include the creation of computer simulation models to address the research questions. The resulting software tool will be an extensible and modular application capable of addressing and testing policies and altering assumptions for use in related research questions and will be freely disseminated via the Internet. The educational plan involves the reuse of the core research computer simulation models with some model simplifications and the addition of common graphic interfaces for interaction and experimentation. The objectives of the education component are to create experiential learning exercise tools

to aid in student conceptualization of the interaction of policies and complex organizational systems.

Public policy, industry-level organizations, and individual firms all may contribute to the level of technological innovation and new product and process development in various industries. Some industries are characterized by rapid change and innovation and other industries produce few or no changes in product or service offerings over time. What are the mechanisms and policies that will effectively generate greater public benefits than their costs? This research unpacks the underlying mechanisms and factors that affect government policies that attempt to encourage innovation through collaboration among industry participants in both rapid and slow developing industries alike. By understanding more about the impact of industry and environmental factors government can better understand the most beneficial industrial collaboration policies to pursue. Likewise, firms can better understand the impact of collaboration on their competitive positions and strategy efforts. Can public policy foster increased levels of investment in innovation while at the same time discourage an anti-competitive environment?

Broad cooperation between industry members can take many forms: consortia, strategic alliances, joint ventures, production agreements, marketing agreements, licensing deals, etc (Gulati, 1995; Powell, Koput, and Smith-Doerr, 1996; Osborn and Hardoorn, 1997). However, community or population-level cooperative processes and knowledge development are powerful vehicles for innovation that have hardly been explored in the literature (Miner & Haunschild, 1995; Miner & Anderson, 1999). Industry consortia may play roles in developing new technologies, setting standards or norms, or interoperability parameters, etc. These and other collaborative efforts, whether initiated by government or member firms, may foster or hinder the level of innovative products and services offered to the public and the national and global economies. How powerful is the role of interorganizational collaboration in increasing innovation? Particularly, in information technology driven industries that have been characterized by many small startup companies, can collaboration benefit the industry participants, the industry as a whole, or foster industry growth? Is innovation increased overall when consortia are formed or do collaborative efforts thwart innovation and

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growth? Are start-up firms or larger incumbents more likely to join and benefit from industry consortia?

Some populations of firms develop these cooperative processes (i.e., R&D consortia) that become institutionalized within their industries (Miner and Haunschild, 1995). Miner and Anderson (1999) suggest that industry-level organizations or consortia may facilitate the population-level diversity requisite for innovation. Sakakibara's (1997) study of government-sponsored Japanese R&D consortia suggest that opportunism or anti-competitive behaviors were not problematic, however, benefits of consortia were modest. Other researchers found that of 350 US industries sampled, collaboration organizations such as R&D consortia existed in fewer than 70 and that "generalist" consortia have an advantage over "specialist" consortia in terms of founding and growth (Barnett, Mischke, & Ocasio, 2000). Other research specific to the telecommunications industry suggests that firms join information technology R&D consortia, not only for the R&D output of the consortia, but to find suitable joint venture or alliance partners by attending membership meetings (Rosenkopf, Metiu, & George, 2001).

This project addresses whether changes in public policy can cultivate basic and applied research in some types of populations of organizations. Can public policy and government actions act as a catalyst to the discovery of new and groundbreaking products and services? Organizations face a challenging balance of supporting research and development consortia versus protecting valuable organizational knowledge. Industry-level organizations and public policy experts face a challenge of facilitating innovation and competition without systematically disadvantaging one or more segments of any population.

Mezias and Eisner (1999) explore the implications of Haunschild and Miner's (1997) frequency, trait, and outcome population-level learning mechanisms to develop theory that considers the effects of environmental carrying capacity, the costs associated with organizational search and change, and environmental change, including both frequency and magnitude on organizations. Other researchers have investigated other considerations that may impact population-level learning. For example, Ginsburg, Larson, and Lomi's (1999) simulations are based on the prisoner's dilemma game. Their findings indicate that the initial proportion of firms that engage in cooperative strategies influences the number of firms joining an industry consortium. Their results can be interpreted to suggest that a geographic nexus or a cognitive community of practice may underlie firm level decisions to join industry-level organizations (Lant and Phelps, 1999).

In attempting to understand the impact of population level cooperative routines on competition and imitation, we adopt a Schumpeterian perspective. Thus, developers of new technologies or processes play a key role in moving an economy towards the production of more valuable goods (Nelson and Winter, 1982). This is an appropriate choice

because the analyses from this perspective have been concerned with the role of innovation in an economy. Competition and imitation are essential ingredients in the central role of innovation of an economy suggested by a Schumpeterian perspective. This research embraces the organizational learning perspective as the basis for modeling firms (Levinthal and March, 1981; Lant and Mezias, 1990). In short, an adaptive organizational learning model implies three major sets of routines that organizations follow (Cyert & March, 1992). First, organizations have performance aspirations to which they compare their current organizational performance. Organizations analyze their performance feedback and scan their environment to assess their level of goal realization. Second, organizations search for alternative strategies under conditions of failure, where the process of gathering and processing information about alternative behaviors is relatively costly. Third, organizations change their strategies based on alternatives selected by their search processes. This research adds a fourth type of search in populations of firms that develop cooperative processes that become institutionalized within their industries (Mezias and Eisner, 1999; Miner and Anderson, 1999). In these populations, firms may choose to search their own or other populations or industries institutionalized processes, i.e., population level search.

METHOD

This model marries an elaborate model of individual firm behavior (Levinthal and March, 1981) with interorganizational concepts drawn from Nelson and Winter's (1982) conceptualization of the Schumpeterian approach to innovation and models the interorganizational concepts of competition and imitation. As with Mezias and Glynn (1993; 1995) the basic decision rules of the simulation program by Levinthal and March (1981) serve as a foundation for our model of individual firm behavior. Mezias and Eisner (1997) offer an operational model for the implementation of interorganizational interaction.

Consortium structures vary widely in industry. However, in this model we simplify the consortium to one that acts similarly to firms in terms of operational and search behavior. The consortium collects inflation-adjusted fees from member firms and uses the aspiration-level adaptation model that individual firms use to allocate resources to innovation, refinement, and imitation searches. Throughout the course of this research project, better models of consortia behavior will be developed (e.g., multiple consortia in one population, selective membership policies, government founded vs. firms, size of founders, etc.). However, initially consortium members will be selected by random draw at the initialization of the simulation and remain members while the firm is alive. However, the work of Sakakibara (1997, 2000) offers hope of constructing a more robust model of firm level entry and

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exit decisions from the consortium or a multi-consortium model and may occur in some industries (Barnett, Mischke, & Ocasio, 2000; Sakakibara, 2000). The consortium will seek out technologies on behalf of its member firms and make its best search efforts available to the members who may select the consortium's inputs in a manner similar to the way they go about imitating their competitor's technologies.

In this study, the full range of imitability is explored by having a parameter of imitability, which we refer to as I , set randomly between zero and one during each run of the simulation. This parameter determines the probability that a firm will successfully obtain an innovation draw as the result of engaging in imitative search. A value of close to one would represent a situation of high imitability, while a value close to zero would represent a situation of low imitability (Mezias and Eisner, 1997). The probability of successfully obtaining an innovation draw was operationalized in conformance with Nelson and Winter (1982: 282): "An innovation draw will, with certainty, enable a firm to copy prevailing best practice."

It is assumed that competition directly reduces the returns that firms earn as a result of using a given technology for the production of goods or services (Nelson and Winter, 1982). However, the elaborate market structure and firm decision-making with respect to capital acquisition modeled by Nelson and Winter (1982: 281-287) is not included in this study. Instead, a simpler operationalization of competition, agnostic with respect to the mechanism by which firm returns are reduced with each new entrant to the market, is used. The model includes a parameter of competitive intensity, CI , that determines the impact each entrant has on the returns of all other firms using substantially similar technologies. Higher levels of this parameter represent greater competitive intensity in terms of the entry of a competitor having a stronger negative impact on the returns of other firms using a substantially similar technology; this is our operationalization of competition.

As competition becomes more intense within the simulation, there is a possibility that returns to a technology will become negative due to the number of firms producing a substantially similar product or service. Negative performance reduces the level of resources possessed by the firm, which also are reduced by the execution of costly innovative, refinement, and imitative searches. Prolonged negative performance in this context can lead to bankruptcy. These bankrupt firms are removed from the population as of the period in which they become bankrupt and are not replaced. Bankrupt firms are not included in the computation of any of the variables of interest that will be discussed in the context of the results of the simulation.

Our interest is in the question of how the propensity of firms to refine their current technologies, imitate others, and develop innovative technologies will be affected by consortium membership. Firms will be randomly assigned to either consortium membership or non-member status.

Following the Mezias and Eisner (1997) definition of competition, this project will vary both the level of competition and the level of imitability independently. This enables us to look at the effect of each variable alone as well as their interaction to augment our understanding of the basic effects of industry consortia on innovation, imitation and refinement behaviors of organizational populations.

TEACHING SIMULATION

The educational plan is to develop new teaching methods and tools to aid student learning of complex decision-making tasks. There are many approaches to teaching complex theories and decision-making. However, an experiential exercise allows students to make decisions and take actions in a realistic virtual environment, thus engaging students in the learning process. While they are at the helm of a virtual policy organization or firm, students are aided in the process of translating their understanding of a situation into actions and then watching the impact of the policies they have selected on the industry. This non-threatening, yet real life decision-making environment facilitates students' conceptualization of complex policies and organizational theories introduced in readings and lectures. This virtual grounding of the theoretical material or theory-in-action experience allows students to form a richer understanding of the decisions that they make and the impact of otherwise abstract concepts. This plan involves the reuse of the research computer simulation models with some model simplifications and the addition of common graphic interfaces for interaction and experimentation. The objectives of the education component are to create experiential learning exercise tools to aid in student conceptualization of the interaction of policies and complex organizational systems.

While there are a number of potentially fruitful curricular uses and courses for this software tool, I will initially develop supplemental teaching materials and enhancement for the existing graduate business curriculum. I have targeted three courses for use with the tool: graduate strategic management capstone course, graduate business and society course, and graduate entrepreneurship course. During the session or modules where these courses usually discuss collaborative strategic moves and countermoves, the supplemental lecture materials, along with the use of the simulation tool, will be used. While the application of the simulation differs somewhat for each course, strategy, business and society, and entrepreneurship were selected in part based upon my domain expertise, institutional needs and support, as well as course relevance. At first the I will use in-class demonstrations of population and individual firm results from the simulation under high and low product imitability or high and low competitive intensity conditions to aid in class discussions. As student feedback is solicited and additional interface elements are developed for the simulation tool, these sessions will become more interactive

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and hands-on for students. This will eventually lead to students altering environmental conditions and assumptions with the software and analyzing their own models to understand the impact of decisions and circumstances.

Using a graphical interface, students will be able to create and test assumptions and policies and visualize the impact of their choices for a simulated timeline. Students will be able to setup environmental conditions to mimic industries that they research as class projects and input those conditions into the simulation and test new government policies that they may develop. I will then use the lecture materials and exercises from the graduate courses along with qualitative and quantitative feedback from graduate students to design and simplify or modify the materials and software tool for use in the undergraduate versions of these courses. I will seek the same qualitative and quantitative feedback from undergraduate students and modify the software and course materials as appropriate.

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