PIES-II
Manual for Innovation Evaluation

Gerald G. Udell
Kenneth G. Baker

University of Wisconsin
Small Business Development Center

PIES-II
Manual for Innovation Evaluation

For use with:
PIES-II: A preliminary innovation evaluation system for estimating risk/potential in new product commercialization.

by Gerald G. Udell
and Kenneth G. Baker

Wisconsin Innovation Service Center

College of Business and Economics
University of Wisconsin-Whitewater

A Service of the University of Wisconsin
Small Business Development Center

Implementation funding provided by the Wisconsin Private Sector Initiative Program, under a grant through the Comprehensive Employment and Training Act of 1978

Produced by the University of Wisconsin-Extension.

Manufactured in the United States of America.

AN OBSERVATION

The precepts upon which the concept of innovation evaluation and this Manual are based are not new. In fact, they are centuries old. They have lost none of their validity.

-- "Without counsel purposes are disappointed, but in the multitude of counselors they are established." (Proverbs 15:22, KJV)
-- "But don't begin until you count the cost. For who would begin construction of a building without first setting estimates and then checking to see if he has enough money to pay the bills? Otherwise he might only complete the foundation before running out of funds, and then how everyone would laugh." (Luke 14:28, LB)

FOREWORD

In a very real sense, technological innovation represents a key to the survival of modern society. Without technological innovation, many of our current crises will remain unsolved and all nations will face an inevitable decline in their natural resources and their standard of living. Thus, it is critical that incentives for stimulating technological innovation be developed and provided for the nation's inventors and innovators.

This monograph describes the invention and innovation evaluation system utilized by the Wisconsin Innovation Service Center (WISC). It is being published in the hope that this decision-theory based evaluation system will stimulate technological innovation by:

1. Providing an effective and efficient starting point for encouraging communication of meritorious technology; and
2. Providing inventors with greater insight into the innovation process.

The original Preliminary Innovation Evaluation System (PIES) was developed by the authors at the experimental innovation center at the University of Oregon under a seven-year grant from the National Science Foundation, with supplemental funding from the National Bureau of Standards and the Small Business Administration. PIES-II, based on six years of research and experience, is the third generation of this program. Its predecessor, PIES-I, was used to evaluate over 5,000 ideas and inventions. PIES-II incorporates several major improvements not available in previous editions.

Major support for the PIES-II project came from the University of Wisconsin. Implementation funding was provided by the Wisconsin Private Sector Initiative Program through a grant from the Comprehensive Employment and Training Act of 1978.

The statements and opinions contained herein are those of the authors and do not necessarily reflect those of the University of Wisconsin System or other agencies involved in prior research efforts.

INTRODUCTION

This manual is intended to provide a brief discussion of the Preliminary Innovation Evaluation System and each of the thirty-three criteria contained in the PIES-II system. The purpose of this manual is to provide the reader with an explanation of the industrial innovation process, the PIES-II system, and some of the factors that influence success or failure of a new product, process, or service. It aims also to:

(1) Provide inventors (who are generally "technically" oriented) with an overview of the key factors that influence commercial success or failure; and to
(2) Acquaint evaluators with the use of the system in order that they may provide the most meaningful information to both inventors and innovators who commercialize inventions.

A better understanding of the innovation process on the part of inventors has two major benefits. First, it greatly facilitates the communication of evaluation results back to the inventor. Feedback to inventors is critical in maintaining a supportive environment for inventors. The lack of adequate feedback is a frustrating and discouraging experience for corporate and non-corporate inventors alike. In addition, proper feedback can stimulate creative activity. Second, inventors who have an appreciation for the innovation process are apt to be more productive. They are not as likely to waste time pursuing ideas that are not viable. Thus, their output can be expected to be of higher quality.

Chapter One introduces the reader to the industrial innovation process. Chapter Two presents the rationale for the evaluation system. Chapter Three provides the instructions for using the evaluation

system presented in Chapter Four. Chapters Five through Nine follow the same format, and are organized to reflect the groupings presented in Chapter Four. Chapter Ten provides instructions for interpreting evaluation results. Chapter Eleven discusses the gap between inventors and industry and suggests some strategies for narrowing this gap. Chapter Twelve goes beyond the idea-evaluation stage and examines the patent process, idea promoters, and sources of inventor assistance. Chapter Thirteen provides a selected annotated bibliography of books and articles relating to new-product development and new venture start-up.

In chapters Five through Nine a brief discussion of each criterion prefaces the question as stated in the Evaluation Format. Following each question is a short interpretation of the possible responses to that question.

"Don't know" and "Not applicable" responses, however, are omitted. A "DK" response indicates that the evaluator lacks sufficient information or expertise to answer the question. A "NA" response means the evaluator feels that the specific question is not relevant when applied to the idea/invention under evaluation. In several cases, responses are identified as critical. This means that this criterion is sufficiently important to negate any positive responses to other questions. For example: Consider the outcome of an evaluation of an automobile driven by a perpetual-motion engine. In spite of the possible high responses in such areas as "use pattern compatibility," "social benefit," "legality," or "long-run profitability," the overall potential for this invention might well be zero. In this case, the critical factor would be "technical feasibility." This assumes, of course, that the inventor had not succeeded in overcoming that age-old law of physics

which states that a machine cannot run without some form of energy input.

The presence of one or more negative critical factors does not always mean that an invention should be abandoned. It does mean, however, that:

A. Further development would be very risky; and
B. This factor should be investigated more thoroughly and resolved before additional funds or effort are expended on the project.

If the difficulties associated with the critical factor cannot be resolved, then abandonment of the project is normally the best course of action.

CHAPTER 1
THE INDUSTRIAL INNOVATION PROCESS

Introduction

Since the Industrial Revolution industrialized societies have tended to look upon industrial innovation as a key, if not the key, to a higher level of living. Technological advances such as the automobile, radio, X-ray, and integrated circuits give credence to these expectations. In addition to the benefits provided by these advances, the economic benefits in the form of new jobs and increased productivity make industrial innovation a continuing worldwide priority.

However, with the dawning of a new decade in 1980 industrial innovation has taken on a new role: that of protecting our current level of living against the ravages of inflation, recession, raw material shortages, and urban and rural decay. The urgency to improve our standard of living has been overshadowed by the urgency to maintain what we already have. Obviously, technological innovation is not going to create a perfect society, nor is it likely to correct social and economic problems rooted in the imperfect nature of man. To look to innovation for the solution of such problems is to look in the wrong direction. On the other hand, new investments of time, creative talent, and financial resources will, as in the past, continue to pay large dividends to those willing to invest them.

Without innovation, we face a future of inevitable decline. As a matter of national policy, we must continue to innovate at an increasing rate, if we are to achieve solutions to social, economic, environmental, and material-shortage crises.

Distinguishing Between Invention and Innovation

The words "invention" and "innovation" have created considerable confusion. Perhaps one of the reasons for this confusion is that they have been used as equivalents. Before we examine the sources of technological innovation, it's appropriate that we pause to distinguish between "invention" and "innovation."

An invention--a new concept, discovery, or device --is only the beginning. It has value only if it is put to use by society as (1) a building block for further developments (i.e., inventions) or (2) a new process, product, or service (i.e., innovations). All of those activities, including invention, which precede the innovation are part of the innovation process. Therefore, while invention is a necessary precedent to innovation, it is not sufficient to complete the process. The "residual argument" concept applies here. If one wants to know the meaning and purpose of a phenomenon, it is necessary to look at the final outcome. Paul Billheimer gives us an appropriate example:

> The automobile was once but a concept, an idea, a dream in the mind of a man. But that idea gave rise to a great enterprise. To manufacture the automobile, huge building complexes covering thousands of acres of land have been erected at astronomical cost. These plants have been fitted with sophisticated machines, tools and equipment, involving enormous amounts of capital. The operation requires limitless raw materials of many kinds from around the world in proportions that stagger the imagination. These industrial complexes employ millions of men and women from engineers to assembly

> line operators. And all of this for one purpose and one alone: a tiny automobile. When the first small vehicle comes from the assembly line, the purpose of this vast conglomerate of industries becomes perfectly clear. All that has gone before, including the huge amounts . . . everything from the drawing board to the last bolt, is illuminated by one thing and one thing alone: the existence of a motor car.[1]

An innovation is "a complex series of activities. . .where the original idea is conceived, proceeding through a succession of interwoven steps of research, development, and management decision making . . .culminating when a product, which might be a thing, a technique, or a process, is accepted in the marketplace."[2]

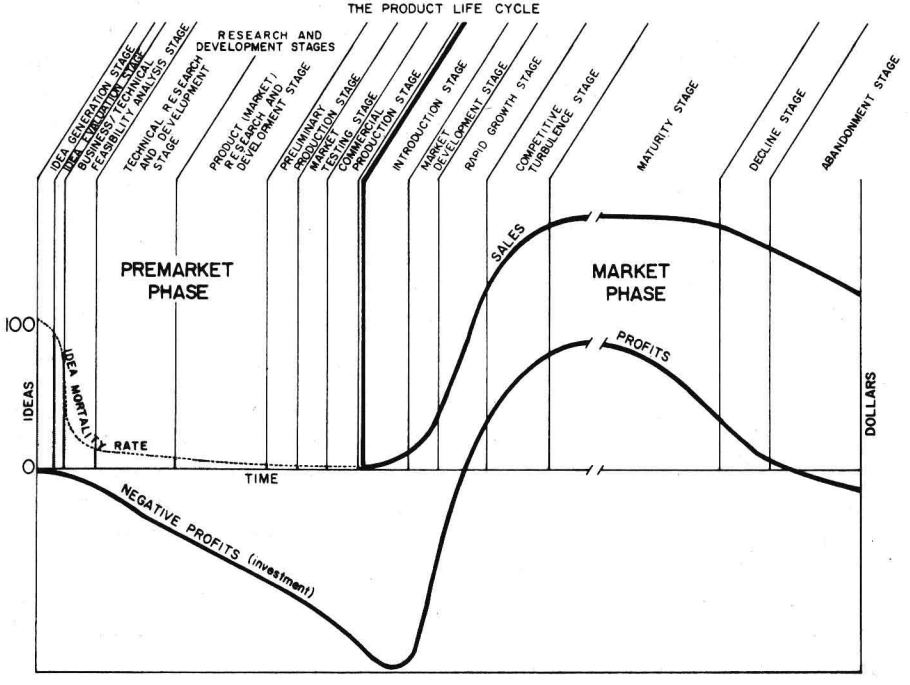
The Nature of the Industrial Innovation Process

This definition of "innovation" can be graphically presented as a sequence of events or cycle through which virtually every new product passes (see Figure 1).

It follows from this definition that an innovator must possess or have access to interdisciplinary skills and resources in order to complete the innovation process. For example,

- At the idea stage, creativity is the essential element; whereas,
- At the technical R & D stage, technical expertise is significant; and
- At the market introduction stage, marketing skills are of paramount importance.

Figure 1
The Innovation Process



The innovation process is a chain, which in a specific situation is only as strong as its weakest link.

Slowdown in Industrial Innovation

Applying this analogy to industrial innovation, we find that:

- corporations may have the bulk of the substantial technical, financial, and managerial resources essential to the latter stages of the innovation process. They lack, however, the creativity and entrepreneurial spirit so essential to the early stages. As a result, they tend to be cautious and conservative and devote their immense resources to pursuing incremental improvements instead of venturing into the risky world of real innovation.[4,5,6]
- non-corporate (independent and small business) inventors, on the other hand, frequently have little more than creativity and a high propensity to take risk going for them as they enter into the innovation process.

In both cases the result is the same--a slowdown in industrial innovation. Increasing government regulation (particularly in the more technologically advanced nations), higher cost, advanced technological sophistication, and greater market complexities have all tended to exert negative pressure on industrial innovation. As West German scholar of innovation Gerhard Mensch put it: "Today a set of mental and material constraints holds the economic systems of the modern industrial nations in their grip. Thus, the resulting business stagnation is a world market phenomenon."[7]

Business Week, in agreeing with Mensch, places the blame on the supercautious attitude of (corporate) management.[8] Until such time that corporations and established institutions develop the entrepreneurial spirit upon which industrial innovation feeds, small business and independent innovators may continue to be the major source of products, processes, and service.

The Role of Independent and Small Business Inventors and Innovators in Industrial Innovation

Historically, small firms and independent inventors have played a major role in technological development. Jacob Rabinow, chief of the Office of Invention and Innovation at the National Bureau of Standards, has stated that most of the major inventions of this century, with the exception of the transistor and color television, have come from individual inventors.[9] Examples abound. Of the eleven major inventions in the steel industry, four were from Europe and seven resulted from the effort of independent inventors; all seven major inventions in the refining and cracking of petroleum were made by independent inventors; and in aluminum welding, fabricating, and furnishing, the major producers accounted for only one in seven in a group of 149 important inventions.[10] The McDonald's and Kentucky Fried Chicken fast-food franchise chains did not spring from the already established Howard Johnson's or the A & W's but from the entrepreneurial efforts of a restaurant equipment salesman and senior citizen who used his social security checks to start a new venture. F. M. Scherer cites several studies which give the large corporation credit for no more than a third of the important recent inventions, and "show that small firms, academicians, and even the totally independent inventor (once assumed to be extinct) continue to contribute heavily toward the creation of new products and processes."[11]

Similarly, in a 1977 study, the Office of Management and Budget concluded that "firms with less than 1,000 employees accounted for almost half of the major U.S. innovations during 1953-1973."[12] This finding is supported by a similar conclusion in an NSF study.[13] The OMB study also concludes that firms with

100 or fewer employees accounted for 24 percent of the major innovations.

Barriers to Small Business and Independent Inventors and Innovators

Despite their still significant contributions these inventors and innovators face considerable barriers. First, the act of invention has become complex. Many inventions involve sophisticated development. In addition, today's marketplace is more complex. Regulations, product standards, production, finance, and marketing pose problems often beyond the capabilities of the individual inventor or entrepreneur. Second, the cost of innovation has skyrocketed. Regulation and inflation have been major contributors to the high cost of new-product development and introduction, which in the United States may amount to as much as $50 billion annually,[14] and may "average" as much as $250,000 for a single new-product offering. Third, the new-product failure rate remains high, an estimated 37%[15] to 80%.[16] The result is that almost four-fifths of all the dollars committed to new-product development[17] are spent on unsuccessful products.

Independent inventors face additional barriers not faced by their small business counterparts. First, the marketplace is, to a degree, hostile to ideas from independent inventors. Most companies prefer to pursue an orderly, internal program of product development that reflects the needs, mission, and direction of the company. Outside ideas represent a public relations headache and a legal hazard to the corporation. Corporate inventions disclosure documents tend to be one-sided affairs which provide little protection for the rights of the inventor[18] (see Chapter 11).

A second and in many instances an equally serious obstacle to independent inventors has been the high incidence of inefficiency, ineffectiveness, and fraud among the so-called idea promotors. Providing questionable patent searches and application assistance, bogus marketing research, and all but totally ineffective technology transfer assistance, these firms have been highly successful in attracting inventor clients (see Chapter 11).

The Gap Between Idea and Innovation

Many people fail to recognize that the innovation process is complex, costly, and time consuming. The complexity is a result of the many variables that have to be considered and dealt with at each stage. The cost of progressing through the many stages grows due to the increased complexity of each succeeding stage and the greater number of people and financial resources that must be used to do a thorough job. Costs may vary from a few thousand dollars to many millions, depending on the interrelationship of the product's level of technological sophistication and the difficulty of entering the marketplace. The time necessary for an idea to reach the marketplace can vary from a few weeks to several decades, with the average being several years. This time frame is a result of having to follow a sequence of stages consecutively during the innovation process. Rarely can any of the stages be completed concurrently.

Many inventors believe that the leap from the Idea Generation Stage to the Market Introduction Stage is only a short distance. Often the inventors assume that they can circumvent the in-between stages by contacting a business firm which will push the idea through the innovation process. Unfortunately, an inventor soon discovers that is rarely the case. Even