1

Overview

It has long been assumed that product innovations are typically developed by product manufacturers. Because this assumption deals with the basic matter of who the innovator *is,* it has inevitably had a major impact on innovation-related research, on firms' management of research and development, and on government innovation policy . However, it now appears that this basic assumption is often wrong.

In this book I begin by presenting a series of studies showing that the sources of innovation vary greatly. In some fields, innovation users develop most innovations. In others, suppliers of innovation-related components and materials are the typical sources of innovation. In still other fields, conventional wisdom holds and product manufacturers are indeed the typical innovators. Next, I explore why this variation in the functional sources of innovation occurs and how it might be predicted. Finally, I propose and test some implications of replacing a manufacturer-as-innovator assumption with a view of the innovation process as predictably distributed across users, manufacturers, suppliers, and others.

The Functional Source of Innovation

Most of the studies in this book use a variable that I call the functional source of innovation. This involves categorizing firms and individuals in terms of the *functional* relationship through which they derive benefit from a given product, process, or service innovation. Do they benefit from using it? They are users. Do they benefit from manufacturing it? They are manufacturers. Do they benefit from supplying components or materials necessary to build or use the innovation? They are suppliers. Thus, airline firms are users of aircraft because the benefit they derive from existing types of aircraft—and the benefit they would expect to derive from innovative aircraft as well—are derived from use. In contrast, aircraft manufacturers benefit from selling aircraft, and

TABLE 1–1. Summary of Functional Source of Innovation Data

Innovation Type Sampled	Innovation Developed by: User	Manufacturer	Supplier	Other	NA[a] (n)	Total (n)
Scientific instruments	77%	23%	0%	0%	17	111
Semiconductor and printed circuit board process	67	21	0	12	6	49
Pultrusion process	90	10	0	0	0	10
Tractor shovel–related	6	94	0	0	0	16
Engineering plastics	10	90	0	0	0	5
Plastics additives	8	92	0	0	4	16
Industrial gas–using	42	17	33	8	0	12
Thermoplastics–using	43	14	36	7	0	14
Wire termination equipment	11	33	56	0	2	20

[a]NA = number of cases for which data item coded in this table is not available. (NA cases excluded from calculations of percentages in table.)

they would expect to benefit from an innovative airplane product by increasing their sales and/or profits.

Of course, the functional role of an individual or firm is not fixed; it depends instead on the particular innovation being examined. Boeing is a manufacturer of aircraft, but it is also a user of machine tools. If we were examining innovations in aircraft, we would consider Boeing to have the functional role of manufacturer in that context. But if we were considering innovations in metal-forming machinery, that same firm would be categorized as a user.

Many functional relationships can exist between innovator and innovation in addition to user, supplier, and manufacturer. For example, firms and individuals can benefit from innovations as innovation distributors, insurers, and so forth. As we will see later in this book, any functional class is a potential source of innovation under appropriate conditions.

Variations in the Source of Innovation

Novel ways of categorizing innovators are only interesting if they open the way to new insight. The first clue that the functional source of innovation is a potentially exciting way to categorize innovators comes with the discovery that the source of innovation differs very significantly between categories of innovation. Consider the several categories of innovation my students and I have studied in detail over the past several years (Table 1–1). In each study summarized in Table 1–1 the innovator is defined as the individual or firm that first develops an innovation to a useful state, as proven by documented, useful output.

Note the really striking variations in the functional source of innovation between the several innovation categories studied. Major product innovations

in some fields, such as scientific instruments, are almost always developed by product users. In sharp contrast, product manufacturers are the developers of most of the important innovations in some other fields, and suppliers in still others (chapters 2 and 3).

An Economic Explanation

The observation that the functional source of innovation can vary is interesting in itself. But if we can understand the cause(s) of such variation, we may be able to predict and manage the innovation process much better.

There are many factors that influence the functional source of innovation. But we need not necessarily understand all of these in order to understand this variable usefully well and to predict the sources of innovation usefully often. As the reader will see, I propose that analysis of the temporary profits ("economic rents") expected by potential innovators can by itself allow us to predict the functional source of innovation usefully often (chapter 4).

This basic idea will certainly not be a surprise to economists. If it is to be useful in this context, however, certain preconditions must be met,* and expectations of innovation-related profits must differ significantly between firms holding different functional relationships to a given innovation opportunity. Since little is known about how firms formulate their expectations of profit from innovation, I have explored this matter in several detailed case investigations (chapter 5).

In all cases studied, it did appear that innovating firms could reasonably anticipate higher profits than noninnovating firms. The reasons for such differences varied from industry to industry. Interesting hints of general underlying principles did emerge, however, and sometimes these were related to the functional relationship between innovator and innovation. For example, users often had an advantage over other types of potential innovator with respect to protecting process equipment innovations from imitators. (Users often can profit from such an innovation while keeping it hidden behind their factory walls as a trade secret. This option is seldom available to manufacturers and others, who typically must reveal an innovation to potential adopters if they hope to profit from it.)

Understanding the Distributed Innovation Process: Know-how Trading Between Rivals

Once we understand in a general way why the functional sources of innovation may vary, we can graduate to exploring the phenomenon in greater

*I discuss and test conditions later; two, however, may convey the flavor. For an economic model of the functional source of innovation to predict accurately, it is necessary that potential innovators (1) not be able to shift functional roles easily and (2) benefit from their innovations by exploiting them themselves rather than by licensing them to others.

detail. Are there general strategies and rules that underlie how expectations of economic rents are formed and distributed across users, manufacturers, suppliers, and others? If so, we may gain a more general ability to predict how innovations will be distributed among these several functional categories of firm.

It is not clear a priori that useful rules for generating or predicting innovation strategies will exist: Such strategies are themselves a form of innovation, and one may not be able to describe the possibilities in terms of underlying components or rules. The only way to find out, I think, is by field investigation. I have undertaken one such investigation to date and have found an interesting phenomenon—informal know-how trading—that seems to me to have the characteristics of a generally applicable component for innovation strategies (chapter 6).

Informal know-how trading is essentially a pattern of informal cooperative R & D. It involves routine and informal trading of proprietary information between engineers working at different firms—sometimes direct rivals. (Know-how is the accumulated practical skill or expertise that allows one to do something smoothly and efficiently, in this instance the know-how of engineers who develop a firm's products and develop and operate its processes. Firms often consider a significant portion of such know-how proprietary and protect it as a trade secret.) Know-how trading exists in a number of industries my students and I have studied, and it seems to me to be an important phenomenon.

When I model informal know-how trading in terms of its effects on innovation-related profits, I find that one can predict when this behavior will or will not increase the expected profits of innovating firms. I propose that know-how trading between rivals is a general and significant mechanism that innovators can use to share (or avoid sharing) innovation-related costs and profits with rivals. As such, it is one of the tools we can develop and explore as we seek to understand the distributed innovation process.

Managing the Distributed Innovation Process: Predicting and Shifting the Sources of Innovation

Even though our understanding of the distributed innovation process is at an early stage, we should be able to get managerially useful results from it now. Indeed, it would be risky to not subject this work to the discipline of real-world experiment and learning by doing.

Since I have argued that variations in the sources of innovation are caused to a significant degree by variations in potential innovators' expectations of innovation-related profits, two managerially useful things should be possible. First, by understanding how expected innovation profits are distributed, we may be able to predict the likely source of innovation. Second, by changing the distribution of such profit expectations, we may be able to shift the likely source of innovation. If both of these fundamental things can be done, we

would be well along the way to learning how to manage a distributed innovation process.

My colleague Glen Urban and I worked together to test the possibility of predicting the sources of a subset of user innovations: those having the potential to become commercially successful products in the general marketplace. (Not all user innovations have this characteristic. A user will innovate if it sees an in-house benefit from doing so and typically does not consider whether other users have similar needs. In contrast, a manufacturer typically requires that many users have similar needs if it is to succeed in the marketplace with a responsive product.)

The particular context of our test (chapter 8) was the rapidly evolving field of computer-aided-design equipment used to lay out printed circuit boards (PC-CAD).[1] Here we found that we could identify a subset of users that we termed lead users. We found innovation activity concentrated within this group as predicted: 87% of respondents in the lead user group built their own PC-CAD system versus only 1% of nonlead users. We also found that product concepts based on these lead user innovations were preferred by all users and therefore had commercial promise from the point of view of PC-CAD product manufacturers. This result suggests, by example, that prediction of sources of commercially promising innovation may be possible under practical, real-world conditions.

My colleague Stan Finkelstein and I tested the possibility of shifting the source of innovation in the field of automated clinical chemistry analyzer equipment (chapter 7).[2] Differences in clinical chemistry analyzer product designs were found that made some analyzer brands more expensive for innovating users to modify than others. If innovating users were seeking to maximize innovation benefit, we hypothesized that there should be more user innovation activity focused on the economical-to-modify analyzers—for experiments requiring equipment modification.

We tested this hypothesis in several ways and found it to be supported. We concluded that managers may sometimes be able to shift the sources of innovation affecting products of interest to them by manipulating variables under their control, such as product design.

Implications for Innovation Research

When a model fits reality well, data fall easily and naturally into the patterns predicted. I have been repeatedly struck by the clear, strong patterns that can be observed in the data that my students and I have collected on the functional sources of innovation. I hope that this aspect of the findings will not escape the eye of researchers potentially interested in exploring the functionally distributed innovation process.

Can we use the strong patterns identified in the functional sources of innovation to build a better understanding of the way innovation-related profits are captured? It seems to me to be important to do so: The nature and effective-

ness of strategies for capturing innovation-related profits probably have as great an impact on economic behavior as do considerations of transaction costs or economies of scale, yet we know much less about them.

As an example of a strong pattern in the functional source of innovation data worth exploring, consider that my hypothesis simply states that innovations will be developed by those who expect a return they find attractive. But the data show that innovations of a specific type are typically developed by firms that expect the *most* attractive return. Can we build from this to show that those expecting the most attractive returns in an innovation category will invest more and eventually drive out all others over time? If so, we will greatly improve our ability to understand and predict the sources of innovation on the basis of innovation-related profits.

As an example of how a better understanding of real-world patterns in innovation-related profits may help us understand a range of economic issues, consider the matter of why firms specialize. Current explanations of this phenomenon focus on consideration of maximizing economy in production. But in the instance of process equipment, decisions by users to develop their own equipment do not appear to me to be motivated by such make-or-buy savings. Instead, innovating users appear to be motivated by considerations of increased profits they may obtain by having better equipment than that available to competitors. That is, they seem to be motivated primarily by considerations of innovation-related rents.

The research my students and I have carried out to date has primarily focused on product and process categories in which innovator firms have developed innovations on their own and have had only a single functional role with respect to those innovations. (An innovator was typically a user *or* a manufacturer, but not both.) The world clearly has more complex cases in it. In some fields of innovation, firms may customarily join with others to develop innovations cooperatively. In other fields firms may typically be vertically integrated or for some other reason contain multiple functional roles within the same organization. These more complex patterns should be studied. Possibly, but not certainly, we will be able to understand them in terms of the same principles found operating in simpler cases.

In the hope that some colleagues will find further research on the functional sources of innovation intriguing, I provide case materials (appendix). These may serve some as a convenient source of initial data.

Implications for Innovation Management

Innovation managers will, I think, find much of practical use in the research I explore in this book. The fact that the sources of innovation can differ has major consequences for innovation managers, both with respect to the organization of R & D and marketing and to management tools (chapter 9).

Firms organize and staff their innovation-related activities based on their assumptions regarding the sources of innovation. Currently, I find that most

firms organize around the conventional assumption that new products are—or should be—developed by the firm that will manufacture them for commercial sale. This leads manufacturers to form R & D departments capable of fulfilling the entire job of new product development in-house and to organize market research departments designed to search for needs instead of innovations.

Indeed, if a manufacturer depends on in-house development of innovations for its new products, then such arrangements can serve well. But if users, suppliers, or others are the typical sources of innovation prototypes that a firm may wish to analyze and possibly develop, then these same arrangements can be dysfunctional. (For example, one cannot expect a firm's R & D group to be interested in user prototypes if its engineers have been trained and motivated to undertake the entire product development themselves.) Once the actual source of innovation is understood, the nature of needed modifications to firms' related organizational arrangements can be addressed.

New sources of innovation demand new management tools as well as new organization. Marketing research methods traditionally used to seek out and analyze user needs must be modified if they are to be effective for seeking out prototype products users may have developed. Similarly, tools for analyzing and possibly shifting the functional sources of innovation are not in firms' current management inventory and must be developed.

Early versions of needed tools will be found in this book. Obviously, much more work must be done. But I urge that innovative managers not wait for better tools and experiment now. Where patterns in the functional sources of innovation are strong, managers with a good understanding of their industries can get useful results by combining the basic concepts presented in this book with their own rich insights—and they should not be reluctant to do this.

Implications for Innovation Policy

Policymakers will find this research on the distributed innovation process interesting for many of the same reasons that managers will: Attempts to direct or enhance innovation must be based on an accurate understanding of the sources of innovation.

As was the case for innovation managers, government policymakers need new tools to measure and perhaps influence a functionally distributed innovation process, and these have not yet been developed. Pending the development of such tools, however, much can be done simply through an understanding that the innovation process can be a functionally distributed one.

As an illustration, consider the current concern of U.S. policymakers that the products of U.S. semiconductor process equipment firms are falling behind the leading edge. The conventional assessment of this problem is that these firms should somehow be strengthened and helped to innovate so that U.S. semiconductor equipment users (makers of semiconductors) will not also fall behind. But investigation shows (Table 1-1) that most process equipment innovations in this field are, in fact, developed by equipment *users*. There-

fore, the causality is probably reversed: U.S. equipment builders are falling behind because the U.S. user community they deal with is falling behind. If this is so, the policy prescription should change: Perhaps U.S. equipment builders can best be helped by helping U.S. equipment users to innovate at the leading edge once more (chapter 9).

The elements in the example I have just described can clearly be seen as components in a distributed innovation process that interact in a systemlike manner. Eventually, I hope we will understand such systems well enough to have a ready taxonomy of moves, countermoves, and stable states. But even our present understanding of the functionally distributed innovation process can, in my view, help us to advance innovation research, practice, and policy-making.

Notes

1. Glen L. Urban and Eric von Hippel, "Lead User Analyses for the Development of New Industrial Products" (MIT Sloan School of Management Working Paper No. 1797–86) (Cambridge, Mass., June 1986), and *Management Science* (forthcoming).

2. Eric von Hippel and Stan N. Finkelstein, "Analysis of Innovation in Automated Clinical Chemistry Analyzers," *Science & Public Policy* 6, no. 1 (February 1979): 24–37.