

50th Anniversary Article

Technological Innovation, Product Development, and
Entrepreneurship in *Management Science*

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This article is a review of work published in *Management Science* on the topics of technological innovation, product development, and entrepreneurship since the inception of the journal in 1954. We intend the article to serve two goals. First, we hope that it will be useful to doctoral students and researchers interested in understanding what questions have been addressed in *Management Science* in the area of innovation. Second, we hope that the article will be useful to sociologists of science who are interested in understanding how knowledge develops in a field. We organize the literature into 12 themes. We then describe some aggregate properties of the articles. In an online supplement, we present brief summaries of the 250 articles we have identified as falling in the domain of our department.

Key words: research and development; innovation; entrepreneurship; product design; product development; management science

Introduction

In honor of the 50th anniversary of *Management Science*, the editor-in-chief, Wally Hopp, asked us to write a review of the articles published in the journal since its inception on the topics of research and development, innovation, product development, and entrepreneurship. The essay that follows represents our attempt to bring together 50 years of research published in the journal in the areas that now represent the domain of our department.

We intend the article to serve two goals. First, we hope that it will be useful to doctoral students and researchers interested in understanding what questions have been addressed in *Management Science* in the area of innovation. Of course, *Management Science* is not representative of all, or even most, research on innovation. Although our department is focused on issues and not on particular methodologies, the papers published to date reflect a bias for mathematical modeling and/or large-sample data analysis. The papers are also divided between attempts to explain “how the world works” and attempts to provide “optimal” decision support. The decision-support approach perhaps differentiates some of the work published in *Management Science* from that published in other outlets. Second, we hope that the

article will be useful to sociologists of science who are interested in understanding how knowledge develops in a field. As a source of primary data on publications of a single journal in a particular intellectual domain, we hope this article will provide the “facts” that will help researchers to examine how a set of scholars, a particular journal, affiliation to an organization, and bandwagon effects influence the development of knowledge in a field.

The set of papers published on innovation in the last 50 years is vast, comprising 250 articles. As a consequence, we cannot possibly provide a truly comprehensive review. However, we do feel that many of the interesting insights arise from a detailed view of the data. We therefore take a two-pronged approach. First, we organize the papers into themes, list them chronologically within these themes, and in an appendix provide very short summaries of the papers. This presents in essence the “primary data” for the reader, and hopefully is useful in its own right. Second, we perform our own rudimentary analysis and explicitly call attention to some aggregate properties of this collection of articles.

The essay is divided into three remaining sections. The first section describes the methodology we followed. The second section provides an overview of

the themes among the articles. The third section provides some analysis of the aggregate properties of these articles. The online appendix to the article contains brief summaries of the actual articles in a collection of tables (mansci.pubs.informs.org/ecompanion.html).

Methodology

We reviewed all scholarly articles published in *Management Science* from 1954 to 2003 and identified 250 articles that fall within the domain of the current department of Research and Development, Innovation, Product Development, and Entrepreneurship. We reviewed all articles within the scope of the current department, even though many of these articles were not actually administered by the department. We do this for two reasons. First, this department was established in 1970, and many important papers were published before that date. Second, there is significant overlap between our department and several other departments of the journal, including Marketing, Operations and Supply Chain Management, and Business Strategy. Despite this overlap, we felt that a review of the field was more useful than a review of a particular administrative unit of the journal.

We scanned the titles and abstracts of every article published in the journal since its inception for the keywords *entrepreneur*, *entrepreneurship*, *venture*, *product development*, *product design*, *technological innovation*, and *research and development (R&D)*. We also scanned the abstracts to see if the articles fit the domain of our department without using a relevant key word. While we believe that this approach is likely to have identified nearly every relevant article, we are likely to have missed a few articles when article titles are not reflective of content. We explicitly exclude most articles focused narrowly on information technologies, as the Information Systems department will do a review of that domain. Finally, we do not review notes, book reviews, and other short pieces, which may have appeared in the journal over the last half century. The net result of this process is a collection of 250 articles, all of which are cited in the references section of the paper.

Overview of the Articles

The top-level subject of our department is innovation, whether applied to products, technologies, or firms. It includes the creation of products, the commercialization of new technologies, and the birth of new companies. We decompose the broader subject of innovation into 12 themes. For the themes with substantial prior research or with an established academic structure, we further identify several subthemes. The themes and subthemes are listed in Table 1. We also list all of

Table 1 Major Themes and Subthemes Within the Domain of Research and Development, Innovation, Product Development, and Entrepreneurship

| Themes |
|--|
| The role of the individual |
| Organization design |
| The effect of organization structure |
| Communication patterns |
| Decision making |
| Basic research and advanced development |
| Technology strategy |
| Economic approaches |
| Behavioral approaches |
| Strategy process |
| Knowledge transfer |
| Learning |
| Knowledge spillovers and technology transfer |
| Product planning and portfolios |
| Development process management |
| Concept development |
| Product design |
| Adoption and diffusion of innovations |
| Public policy |
| Effect of innovation on economic growth |
| Factors influencing the rate of innovation |
| Tools used by policy makers |
| Impact of Specific Policies |
| Entrepreneurship |
| Decision making |
| Strategy and performance |
| Organization design |
| Venture finance |

the articles we reviewed with very brief descriptions of the research in an appendix that is available in the online version of this article. In the last column of the tables in the appendix, we classify individual papers according to their dominant methodological approach whether empirical, qualitative empirical, conceptual, or a theoretical model.

The Role of the Individual

One of the major themes in the domain of research and development, innovation, product development, and entrepreneurship is the role of individuals. Although this area has been one in which a great deal of research has been published in the fields of management, organization behavior, psychology, sociology, and economics, very little of this work has been published in the pages of *Management Science*. In fact, over the 50-year life of the journal, only five articles about the role of individuals have been published. Moreover, the published work is largely quantitative and does not represent the large amount of qualitative work conducted in the field in general. Rather than appearing in *Management Science*, much of the individual-level work appears to have been published in psychology, organizational behavior, and management journals. Furthermore, only the first of these studies takes the approach of a qualitative case

study; the remaining articles take the more quantitative approach that is common to the journal. As a result, *Management Science* greatly underrepresents the qualitative empirical, individual-level research on innovation.

Organization Design

One of the major themes of research in the domain of research and development, innovation, product design, and entrepreneurship published in *Management Science* over the past 50 years has been that of designing organizations to engage in innovative activity. This research on organization design can be subdivided into three basic subthemes: the effect of organization structure on innovation, communication patterns in innovative activity, and decision making about innovation and technology. The earliest of these subthemes explored in the journal was that of the effect of organizational structure on innovation. This subtheme was one with off-and-on attention over the past 50 years, with the addition of new dimensions periodically reviving the theme. The second subtheme on organizational design explored in the journal was that of communication patterns in innovative activity, which was initially internally focused and shifted to consideration of the external boundary of the organization in the 1980s. The third subtheme—decision making about innovation and technology—witnessed a flurry of studies in the 1970s. A process orientation to studies of decision making about innovation in *Management Science* was introduced in the 1980s. The decision-making subtheme was then dormant in the pages of *Management Science* for over five years, until the early 1990s when researchers began to introduce new ideas to the study of decision making about innovation and new technology. The 1990s also introduced the first formal models of R&D decision making published in *Management Science*.

Basic Research and Advanced Development

Fourteen papers fall under the theme of basic research and advanced development. These are a highly eclectic group of papers, with no critical mass of work emerging on any particular topic. The topics range from time studies of individual scientists to macroeconomic models of R&D spending. At the time our department was formed in 1970, much of what we call “innovation” was labeled “R&D.” This was also a period in which corporations performed a substantial amount of basic research. We draw a distinction between R&D as the product-generation function of the firm and basic research and advanced development, which we define as innovative activities not directed at a specific product-development objective. Relatively little research has been focused on basic research, perhaps because of the decline in prominence of this activity in firms over the last several decades.

Technology Strategy

A fourth major theme on innovation visible in the pages of *Management Science* is technology strategy. What is most remarkable about the theme of technology strategy is that no articles on this theme were published in the first two decades of the journal, and yet this theme has arguably seen the most innovation articles published in the past 50 years. The main reason is the relatively large number of technology strategy articles published in the late 1980s. One reason for the importance of technology strategy research to *Management Science* has been the dramatic rise in its importance within business schools management departments. From virtually nowhere, strategic management became a required business school course in all MBA and undergraduate programs, spurring research in the area, whether or not the focus was on technology. Another reason for the importance of technology strategy research is the fact that many departments of the journal publish it. While our domain examines strategy only as it reflects technology and innovation, it is hard to examine firm strategy in many industries without the consideration of technology and innovation. As a result, many of the papers discussed in our review were accepted by the Business Strategy Department of *Management Science*, and considerable overlap exists with this department in the domain of innovation.

The technology strategy theme can be divided into three subthemes—economic explanations for technology strategy, behavioral explanations for technology strategy, and strategic process. As reflects the emergence of the strategy field within business schools in the 1970s, the first of the economic-oriented strategy articles on this theme appeared in the journal in the 1970s, with *Management Science* publishing many subsequent empirical studies and formal models of technology strategy. The journal has also published several behavioral studies of technology strategy, with the earliest of these examining the PIMS database and subsequent studies expanding to other sources of data. Several behavioral studies of technology strategy sought to identify the source of firm performance, but have considered a variety of topics including: creating new knowledge, the strategy-environment fit, intraorganizational relationships, and the effects of top management team characteristics. The journal has also published several studies of strategy process, which represents a third subtheme of technology strategy research.

Knowledge Transfer

Another theme of articles published in *Management Science* in the domain of our division is knowledge transfer. This theme has focused largely on two subthemes: learning, and knowledge spillovers and

technology transfer. The earlier of these subthemes was learning, which was first tackled in the journal in the 1960s. Moreover, over the past 50 years, several additional studies have been published in *Management Science* on the topic of learning, expanding the approaches toward learning in a variety of ways. A more recent subtheme for *Management Science* is the domain of knowledge spillovers and technology transfer. Only since 1999 has this theme been important in the journal; however, in a relatively short period of time, the journal has published several studies on this topic.

Product Planning and Portfolios

A substantial body of research in *Management Science* has been focused on the question of which innovation projects to pursue. This decision involves both assessing the inherent merit of a particular project and understanding the interactions among projects in determining the overall value of a portfolio of projects. The optimization paradigm so prominent in *Management Science* has been brought to bear on product planning problems over the decades. This theme appears to be the second largest within our department, with 33 published articles. This research stream has continued unabated since the earliest years of the journal. Surveys have shown that these models have found very little use in practice and only two of the articles published are empirical. These observations lead us to wonder if the journal should perhaps be especially selective with respect to work published in this area. If 50 years of research in an area has generated very little managerial impact, perhaps it is time for new approaches.

Development Process Management

We observe an extensive literature in *Management Science* in the area of product development that focuses on managing product development processes. In many ways this focus is natural, given the historical roots of the journal's community in the modeling of operations. Much of this research takes the perspective of a product development process as a collection of tasks with information flows among them. Many of these papers, having formulated production-like models of development processes, then attempt to optimize performance. Perennial questions include the extent to which dependent tasks should be overlapped and the relative value of lead time and efficiency. This body of research has been relatively balanced in terms of methodological approach, with analytical models balanced by empirical studies. Nevertheless, most of this work must be characterized as "insight models," with almost none of it resulting in new decision support tools.

Product Design

We define product design as the set of decisions that define the product itself. We exclude from this category a very large body of work on consumer-attribute-based design methods, including conjoint analysis, which fall solidly within the field of marketing. To some extent this distinction is arbitrary, yet it is reflective both of the way the academic field has been organized and of the way the R&D and marketing functions of most firms are differentiated. *Management Science* has not historically encompassed research on product design, nor was there substantial research on product design within the management research community prior to the late 1980s. Since then, a body of work has germinated around the issues of coordinating product design with production processes, including papers on design for manufacturing, platform planning, and component sharing.

Concept Development

A central problem in product development is which *concept* to pursue. The concept is the configuration of working principles and elements that make up the product, whether a service, software, or a physical good. Included within this category is the genesis of ideas for new products. Much of this research addresses ways in which information from lead users can be exploited to develop new product concepts. Other research focuses on methods for testing new product concepts. This body of research displays the desirable qualities of both being extremely relevant to managerial practice and relying on rigorous analytical techniques.

Adoption and Diffusion of Innovation

An impressive body of research has coalesced around the problem of explaining and predicting the adoption and diffusion of innovation. The extent of this research may be explained by at least two factors. First, a seminal paper by Bass (1969) appeared in *Management Science*. This paper has been cited over 500 times and forms a strong association between *Management Science* and research on diffusion. Second, the models that underlie much of the diffusion literature have their roots in physical diffusion processes, known well in science and engineering. Given the training of much of the management science community, diffusion resonated strongly with the interests and capabilities of researchers with an inclination to publish in *Management Science*.

Public Policy

Another important theme of *Management Science* in our domain is public policy toward innovation. While our domain examines public policy only as it reflects technology and innovation, many important public

policy issues relate to technology and innovation, leading to a concentration of research in this area in the pages of the journal. Some of the papers discussed in our review were accepted by the Public Sector Applications Department of *Management Science*, and considerable overlap exists between our department and that one in this domain. This theme is an old theme in the journal, with the first articles having been published in the 1960s. The first papers on this topic explored the effect of technological innovation on economic growth. Researchers have also explored the factors that influence the rate of innovation in a locale. Another set of studies examined the tools that policy makers use to make decisions about investments in innovation. Starting in the 1980s and continuing through today, *Management Science* has published a variety of articles that look at the impact of specific government policies on innovation.

Entrepreneurship

A final theme of our division of *Management Science* has focused on entrepreneurship, which we further divide into four subthemes: decision making, strategy and performance, organization design, and venture financing. The decision-making subtheme was the first to be discussed in the journal with a formal model of entrepreneurial decision making being published in 1971. However, this subtheme was not discussed again in the journal until 30 years later, and then only by four other studies. A larger subtheme examines the performance of entrepreneurial firms, which has focused in particular on aspects of strategy that enhance the performance of new and small firms. A third subtheme has examined the relationship between the attributes of new firms and their organization design, trying to understand the issues of designing new and small organizations for innovation. A final subtheme of research on entrepreneurship published in *Management Science* focuses on venture finance, seeking to explain how new firms obtain the capital to exploit business opportunities.

Analysis

Several insights arise from analyzing the aggregate properties of the innovation papers published in *Management Science* over the past 50 years.

Publication Rates of Innovation Papers in *Management Science*

Table 2 shows the number of articles published in the field of innovation in each five-year period since the inception of the journal, along with the percentage this number represents of the total number of articles published by the journal overall. In the first five years of the journal, there were no articles about innovation. After that, there was a steady increase in both

Table 2 Number of Articles Published in Domain of Innovation 1954–2003

| Five-year period (starting year) | Number of innovation articles | Percent of total in <i>Management Science</i> |
|----------------------------------|-------------------------------|---|
| 1954 | 0 | 0 |
| 1959 | 1 | <1 |
| 1964 | 11 | 7 |
| 1969 | 16 | 10 |
| 1974 | 23 | 11 |
| 1979 | 27 | 13 |
| 1984 | 42 | 17 |
| 1989 | 35 | 11 |
| 1994 | 25 | 6 |
| 1998 | 70 | 16 |

numbers and percentage from the start of the journal to the late 1980s. At that time the number of articles dropped substantially, and the percentage of the total fell precipitously. Beginning in the late 1990s, the number and percent have grown again to the levels seen in the late 1980s. We believe that the source of the decline and subsequent renewal of interest in articles on innovation was twofold. First, it was the result of an improvement in the quality of research in *Management Science* during the 1980s. Because of the interdisciplinary nature of innovation research, the transition toward more rigorous research occurred more slowly in that area than in other areas, leading to a temporary decline in “market share.” Second, part of the substantial growth in articles in recent years is the result of growth in interest in the subject of innovation across several departments of the journal. As a result, the current innovation research has a broader intellectual base than the innovation research of the early 1980s when levels of this research were also high. A competing hypothesis is that the sudden decline and resurgence in publication rates was the result of individual preferences of the editors over the years.

Changing Themes, but Within Constraints

Table 3 shows the distribution of articles across themes by decade. The table indicates that some themes are clearly more important now than they were when *Management Science* began and some themes have become less important. However, the simple fact that we can account for all of the articles in 12 themes also suggests that the degree of theme change is quite constrained.

Moreover, the journal’s publication is quite lumpy. For instance, there is a very high concentration of articles in the area of adoption and diffusion of innovation. Similarly, there is a high concentration on product planning and portfolios. One reason for this lumpiness is that the journal’s publication reflects its mission and affiliation with INFORMS, making the journal more focused on phenomena that are tractable to formal modeling than is the case for

Table 3 Distribution of Articles Across Themes by Decade

| Themes | Decade beginning | | | | | Total |
|---|------------------|------|------|------|------|-------|
| | 1954 | 1964 | 1974 | 1984 | 1994 | |
| The role of the individual | 0 | 1 | 2 | 1 | 1 | 5 |
| Organization design | 0 | 4 | 11 | 6 | 8 | 29 |
| Basic research and advanced development | 1 | 2 | 3 | 6 | 2 | 14 |
| Technology strategy | 0 | 0 | 3 | 20 | 11 | 34 |
| Knowledge transfer | 0 | 1 | 1 | 2 | 9 | 13 |
| Product planning and portfolios | 0 | 7 | 14 | 9 | 3 | 33 |
| Development process management | 0 | 3 | 1 | 5 | 22 | 31 |
| Product design | 0 | 0 | 0 | 2 | 9 | 11 |
| Concept development | 0 | 0 | 2 | 2 | 7 | 11 |
| Adoption and diffusion of innovations | 0 | 4 | 7 | 13 | 8 | 32 |
| Public policy | 0 | 4 | 6 | 4 | 5 | 19 |
| Entrepreneurship | 0 | 1 | 0 | 7 | 10 | 18 |

other management journals. Another reason for this lumpiness is path dependence. Once a journal begins to publish articles in a particular area, authors tend to submit papers in that area, which are then reviewed by experts in the area who have published previously in the journal, reinforcing the focus on the topic. A third reason is that many of the articles within our domain have actually been accepted by editors of other departments. Many of those departments are likely to accept only those innovation articles that are related to their primary mission, skewing the publication of innovation articles toward certain topics.

Another type of change not represented in the above table is the change in the types of papers published. Table 4 shows the percentage distribution of papers across conceptual, formal, empirical, and qualitative by decade. As the table shows, empirical papers have gained at the expense of all others. We view this shift as healthy, in that many of the modeling efforts have outstripped the empirical observations that motivated them in the first place.

Author Community

We have also identified the authors of the articles in the research and development, innovation, product design, and entrepreneurship domain over the past 50 years. We acknowledge that the count of authors

Table 4 Percentage Distribution of Articles Across Types by Decade

| Types | Decade beginning | | | | |
|---------------|------------------|------|------|------|------|
| | 1954 | 1964 | 1974 | 1984 | 1994 |
| Conceptual | 0 | 7 | 4 | 4 | 1 |
| Formal models | 0 | 41 | 38 | 37 | 36 |
| Empirical | 100 | 38 | 42 | 54 | 57 |
| Qualitative | 0 | 14 | 17 | 4 | 6 |

in this domain is influenced by our process of identifying certain publications and not others as fitting our domain. In addition, readers should not interpret the count as representative of publishing in *Management Science* in general, but only in the innovation domain. With those caveats in mind, however, we do think the authorship patterns are interesting. The publication of research in the research and development, innovation, product design, and entrepreneurship domain has been fairly skewed. Over the past 50 years, there have been 555 authors listed on articles published in our domain; 81 researchers have published more than one article in the journal in this domain over the past 50 years. These 81 researchers accounted for 232 author slots or 41.8 percent of the authorship of articles over the past 50 years. Table 5 identifies the 30 authors who have published the most articles in our domain of *Management Science* since the inception of the journal. We also list the primary institutional “department” (or equivalent organizational unit) for the author. We observe that authors in the field find homes within a wide range of departmental settings.

Discussion

The phenomenon of innovation and its scholarly study have both evolved substantially since 1954.

Table 5 Authors with More Than Three Articles Published in *Management Science* in the Field of Innovation, 1954–2003

| Author | Institutional “department” | Number of articles |
|----------------|----------------------------|--------------------|
| von Hippel, E. | Mgt of Tech | 8 |
| Shane, S. | Economics | 8 |
| Souder, W. | Marketing | 7 |
| Krishnan, V. | Operations Mgt | 6 |
| Ettlie, J. | Operations Mgt | 6 |
| Utterback, J. | Mgt of Tech | 5 |
| Ulrich, K. | Operations Mgt | 5 |
| Rubenstein, A. | Industrial Engineering | 5 |
| Mansfield, E. | Economics | 5 |
| Lee, T. | Economics | 5 |
| Baker, N. | Operations Mgt | 5 |
| Muller, E. | Marketing | 4 |
| McCardle, K. | Tech and Ops Mgt | 4 |
| Mahajan, V. | Marketing | 4 |
| Joglekar, P. | Operations Mgt | 4 |
| Bayus, B. | Marketing | 4 |
| Bass, F. | Marketing | 4 |
| Taylor, B. | Operations Mgt | 3 |
| Srinivasan, K. | Marketing | 3 |
| Oral, M. | Operations Mgt | 3 |
| Moore, L. | Operations Research | 3 |
| Loch, C. | Tech and Ops Mgt | 3 |
| Lilien, G. | Marketing | 3 |
| Kekre, S. | Operations Mgt | 3 |
| Iansiti, M. | Tech and Ops Mgt | 3 |
| Hamburg, M. | Statistics | 3 |
| Freeland, J. | Operations Mgt | 3 |
| Eppinger, S. | Operations Mgt | 3 |
| Eliashberg, J. | Marketing | 3 |
| Adler, P. | Management | 3 |

We have seen a variety of changes in the industrial context in which innovation occurs. In 1954, innovation by firms was largely confined to a very small number of countries, with the United States being quite dominant in this activity. Now, however, innovation is a more global phenomenon with many more countries serving as the locations where technological innovation occurs, and the companies engaged in this innovation undertaking it in a global fashion. Information transfer was much more limited in 1954 than it is today because computers were not widespread in companies, air travel was slower, and many technologies that we take for granted (the most obvious being e-mail) were nonexistent. Of course, this change in the transmission of innovation has greatly affected the innovation process. A variety of other changes have occurred in the industrial context since 1954. Western economies have become less reliant on manufacturing and more reliant on services. Production has become more fragmented, disintegrated, and less based on economies of scale than it was in 1954. It has also become more reliant on information than on physical inputs. Development lead times have accelerated and the creation of new ventures has become more prevalent.

In some ways, the innovation domain of *Management Science* has changed in response to these industrial changes. We have many more papers on service industries than we had in 1954. The study of new venture creation and product design and development takes up a much larger part of the journal's pages than it did 50 years ago. Similarly, the role of information in innovation is a much more central topic now than it was in 1954. However, in other ways, the innovation domain of *Management Science* has changed much less than the business environment. We were surprised by the fact that we were able to identify 12 central themes, only three of which were not discussed before the decade beginning in 1974. To us, this pattern suggests that the authors of *Management Science* articles on innovation are perhaps not innovative enough. We wonder if *Management Science* is focusing its attention too narrowly to adequately represent the scholarly domain of innovation studies.

On the dimension of scholarly rigor, we think that *Management Science* has done a much better job of "keeping up" with research on innovation. Over the past 50 years, the intellectual rigor of business school research has advanced dramatically and *Management Science* has consistently been at the frontier of research on innovation both theoretically and methodologically. As formal modeling has increased in importance, *Management Science* has seen more formal models of innovation. As business school researchers have begun to explore topics such as firm strategy, product design, and entrepreneurship,

rigorous studies on those topics have appeared in the journal. Moreover, as social science disciplinary foci have become more important in business schools, *Management Science* has published more and more disciplinary-oriented research. Finally, the empirical innovation studies have become more rigorous, with much more advanced research designs and statistical methods being employed by researchers.

We have learned a great deal from the exercise of reviewing our domain of the journal over the past 50 years and think that it has given us insights that will make us better editors. We hope that this essay has allowed us to impart some of those insights to readers so that we may all advance the study of innovation, particularly within the pages of *Management Science*.

An online supplement to this paper is available at mansci.pubs.informs.org/ecompanion.html.

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