Changes in the field of R&D management over the past 20 years

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INTRODUCTION AND SOME EARLY HISTORY

To begin, let us quickly review some of the very early history of the field of what was then universally called "R&D Management," and which is now often referred to as "Management of Technology." This will be far from a true historical analysis. It is based primarily on the personal recollections of the senior author. We welcome any additions and corrections which anyone in the audience might like to make.

The earliest work, to our knowledge, was done in the mid-1950s by three people at the Massachusetts Institute of Technology. They were Al Rubenstein, Herb Shepard, and an economist named MacLauren. Since neither of us were there at the time, we have no first-hand knowledge of the degree to which they worked together or considered themselves a group. We only know from their publications that they shared a common set of interests. At any rate, the "group" was short-lived. MacLauren died, and Rubenstein and Shepard departed for other academic pastures. Shepard then drifted into different research interests, but Rubenstein stayed with it and established a program of research at Northwestern University. He has been

actively engaged in research and teaching in the area down to the present time. He is clearly the patriarch of the field. Several of his students are present today to lend testimony to that fact.

A few years after the departure of this initial group, MIT received another chance. In the early 1960s, Jim Webb, the Director of the United States National Aeronautics and Space Administration (NASA), reflecting on the fact that NASA was spending a substantial amount of money in universities supporting basic research in the physical sciences, and seeing that at least half of NASA's problems were managerial, concluded that it might be appropriate to support basic research in the management sciences. He approached MIT about the possibility of establishing a program of research in R&D management, stimulated by a fairly large grant from his agency. Donald Marquis was appointed principal investigator. He was soon joined by Ed Roberts, who had become interested in the field as a graduate student, and by the senior author, who was on leave at that time from industry.

NASA gave similar grants to a total of five universities. All, of course, accepted and established programs. Only two of the programs--one at MIT and one at Northwestern--persisted beyond the life of the initial grant. This, we might add, is an unfortunate characteristic of work in this research area. Researchers are attracted by the occasional availability of

funding but develop no real commitment. Consequently, when funds expire, they return to research in other areas. This has been very much a result of the failure of the business schools to recognize this as a legitimate area of research and teaching. Young faculty, therefore, see this as a risky area in which to become involved. This fact has made it very difficult to establish long-term programs of research. This is a situation which may be changing radically; we will come to that later in the paper.

ACTIVITIES IN THE UNITED KINGDOM

At the same time as this American activity, there were several people in the U.K. who were involved in "research on research." There had been several studies of the innovation process and, of course, the Burns and Stalker study of organization. Just as in the U.S., these efforts were fragmented. They became more concentrated only after the establishment or shift of emphasis of three research groups. Two were here at Manchester. The R&D Studies Unit, in the Business School, was established under Alan Pearson, who had recently joined the school from industry. The Department of Liberal Studies in Science, at about the same time, launched a major study of the process of innovation. Finally, the Science Policy Research Unit at Sussex, under Chris Freeman, which as its title would suggest, was primarily concerned with national policy, moved to a more managerial level with its very important study of

innovation, which it called SAPPHO.

THE BURNING ISSUES OF THE TIME

Eric Ritchie (1970), in the inaugural issue of R&D Management, was kind enough to provide us with an overview of the field as it was then configured. Ritchie began his paper with a disclaimer. He said that little was known concerning the final or exploitation phase of the innovation process and that at that time there was little activity addressing that lack of knowledge. Nearly 20 years later, the first part of his statement still holds true, but we are finally beginning to direct our efforts more toward this important need.

Ritchie went on to discuss five general areas of research and these are a reasonable approximation of what were then the areas receiving the greatest attention at that time (Table 1).

A SHIFT IN TOPICS

To test whether these topics were still considered to be important, we scanned the articles published in R&D Management in 1987 and very unscientifically classified them as falling or not falling into one of the five areas (Figure 1). Fully 72 percent of the papers fell outside of the classification. So the field, as represented in these data, has shifted its emphasis considerably. To test the phenomenon a bit further, we obtained a listing of all of the articles published in R&D Management

Table I Topics Reviewed by Eric Ritchie in 1970.

- THE RESEARCH POOL AND EMBRYO
- CREATIVITY
- COMMUNICATION
- EVALUATION AND SELECTION OF APPLIED RESEARCH PROJECTS
- PLANNING AND CONTROL OF RESEARCH AND DEVELOPMENT

between 1971 and 1987. Again, the articles were very subjectively classified by topic (Figure 2).

This analysis shows a less pronounced but still very definite shift in emphasis and, for us, some surprises. For example, we expected to see an increase in papers addressing strategy issues, at either corporate or R&D levels. In fact these two areas were receiving as much attention in the early 1970s as they are today. R&D strategy was given a great deal of attention in the late 1970s but has more recently fallen to about the same level it was at from 1970-1975.

Moving from topic to topic, we can see that attention given to more general economic issues has been relatively stable over time. This is not to say necessarily that the economics of R&D has lost any importance. What it says is that economists are publishing fewer papers in a journal devoted to general R&D issues and aimed at a combined academic and managerial audience.

Project selection and project management were key issues in the early years. This was shown by Eric Ritchie as well. He devoted more than half of his review to these two topics. They seem less important today. This is not, we might add, the result of all of the problems being solved. As we shall see, the

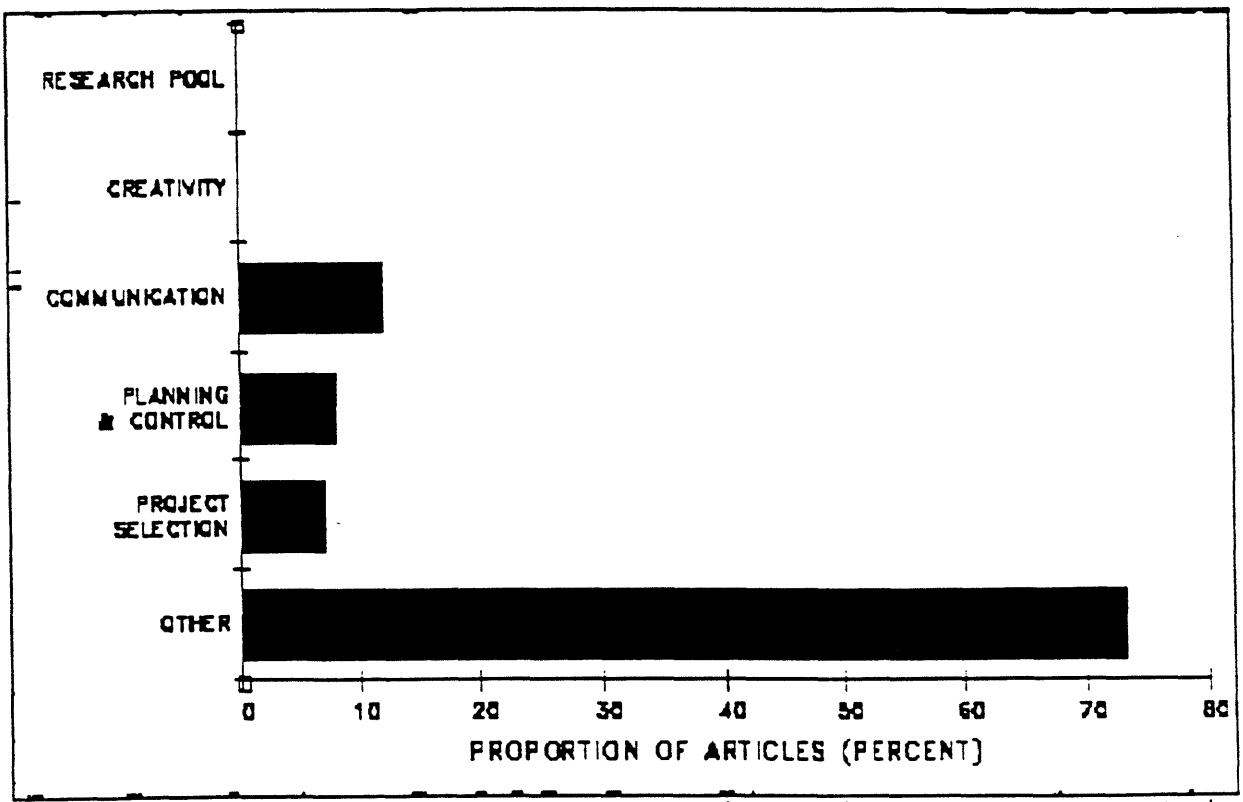

Figure 1 Proportions of Papers Published in R&D Management in 1987 That Fall Into Ritchie's Four Categories.

problems retain their importance in many people's eyes. Rather, the problems are very difficult and are in need of a creative breakthrough.

The popularity of research in communication has varied very

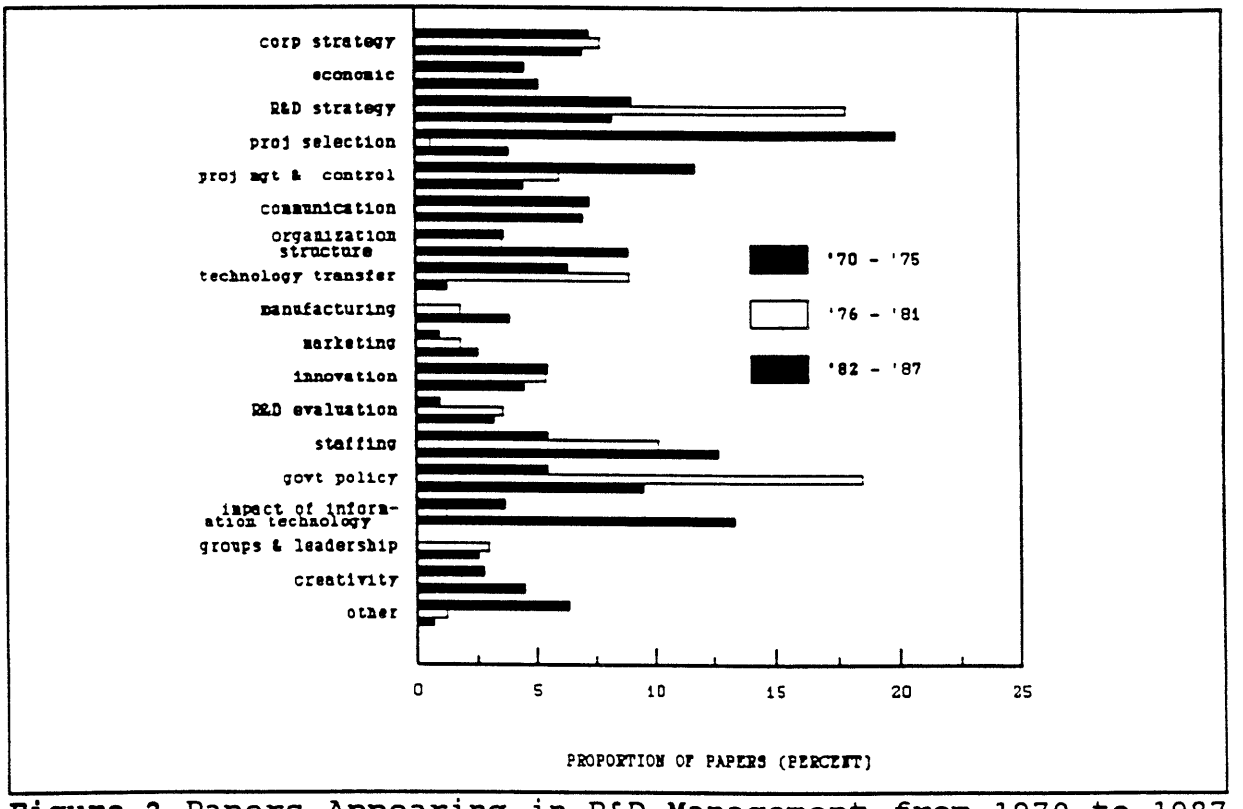

Figure 2 Papers Appearing in R&D Management from 1970 to 1987 Categorized by Topic and Time Period.

little over time and a fair proportion of the papers still fall into this class. The sub-topics within communication have shifted, however. Whereas printed media were the prime target of concern earlier, present emphasis is on communication among functional (i.e., marketing R&D, manufacturing) areas. Much of

this is now labelled "technology transfer," a term which originally implied transfer between organizations or countries. It has come, more recently, to mean transfer of knowledge, information, or detailed designs between sub-units within a single organization. In particular, the term is used to designate the movement of projects and design-related information from product development into manufacturing engineering. We have classified all of this under the general area of communication. As a result, there is less concern exhibited for the more restrictive definition of technology transfer, i.e., the movement of knowledge across corporate or national boundaries.

There has been a surprising increase in the number of papers dealing with organizational issues. Just when some of us thought that we had all of these well understood and the matrix under control, researchers have re-opened the issues. We suspect that were we to look more carefully at the articles themselves, we would find that increased attention is being given to relations within and between organizations in an attempt to shorten product development time.

There has been, in both Europe and the United States, an increased concern with manufacturing and with the relations between product development and manufacturing. This is reflected in the increased proportion of articles currently devoted to this subject. The proportion itself is still relatively small,

however.

While we all acknowledge the importance of marketing, authors publishing in R&D Management have managed to treat it with unfailing neglect over the years. Studies of the overall innovation process, which often had a marketing component, while very popular in early years, have diminished slightly in number more recently. Researchers may believe that there is sufficient knowledge of the process at a global level. They may be taking on more specific issues. The conference in Paris of the Institute of Management Science in early July, 1988, devoted three days to management of innovation, but in spite of the label the majority of papers dealt with strategy.

Staffing of R&D organizations and the motivation and management of highly educated technical professionals continues to be one of the heavily mined areas of research. It was the area that most concerned Rubenstein and Shepard in the early years; it is the area that managers seem most concerned with; it has received much consideration from researchers over the past 20 years, and it remains an important area. Despite all of the attention, we have not come close to solving all of the problems of managing technical professionals.

Government policy has been a subject of considerable interest since at least the mid-1970s. This is somewhat

surprising for a journal devoted to management issues, but shows the high level of interdependence that has developed between government and industry around issues of technology. One has only to look at the plethora of programs, all with catchy acronyms, coming from the European community for evidence of this.

Concern with information, i.e., our growing capabilities in computation and communication, is getting quite a lot of attention but probably not enough. Two important technological advances are certainly occurring at present, and these will have an enormous impact on all aspects of management, certainly, including R&D. Electronic memory is approaching zero cost, and communication bandwidth is rapidly decreasing in cost as well. The resulting improved computer-aided engineering and computer-aided design systems will have an enormous impact on the very nature of the work that we are studying. It would behoove us to devote more research effort to studying this impact.

Turning to our next to last topic, there has been a fairly stable but relatively low interest in the subject of managing technical groups. This is surprising in light of the continuing high interest in managing individual professionals. It is also a disappointing observation, since we believe it to be worthy of continuing high concern. Certainly, there are many problems in this area that are not yet solved. It is reassuring to see that

the present conference is to be followed by a three-day conference on Managing Interdisciplinary Research Groups.

Finally, there is creativity. With the exception of a short void in the mid-1970s, it has received steady but low-level attention. This seems perfectly appropriate. Creativity is very important to R&D management but it has proven a very difficult way to do research. A lot of work was done in the 1960s. But little in the way of new knowledge has developed since then. Like project selection, it is an area awaiting a breakthrough.

COLLABORATION

Since in reviewing topics a number of other measures became available to us, we thought you might like to engage in some further introspection. Looking at collaboration, for example, it is apparent that we don't partake very heavily (Figure 3). We are primarily "loners," and this has not changed very much with time. When we do collaborate, it is with a single partner, probably as in the present instance, a student. Bear in mind that these data are taken from a single journal. But it is doubtful that they would be very different if other journals were considered.

LOCUS OF RESEARCH

The data in the next figure (Figure 4), on the other hand, are considerably biased due to their source. They are

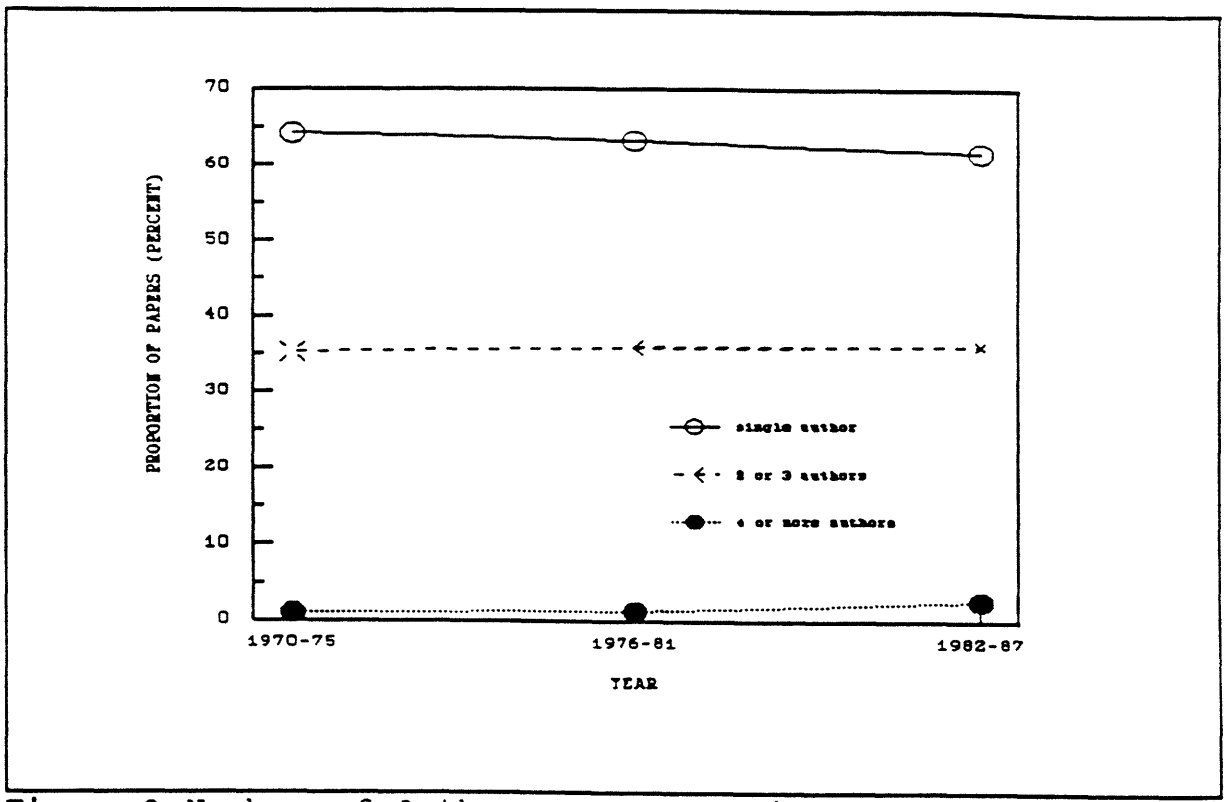

Figure 3 Number of Authors per Paper in R&D Management as a Function of Time.

interesting, nonetheless. There has been a definite shift toward greater internationalization in the pages of R&D Management but only in the form of an American invasion. In the early years, nearly all papers were British-authored. Beginning in the mid-1970s, some authors from continental Western Europe arrived to augment the few Americans. But then they decreased in proportion, while the Americans increased, and authors from other parts of the world increased for a while and then decreased again.

IMPACT OF THE FIELD

An interesting measure provided by Science Citation Index is

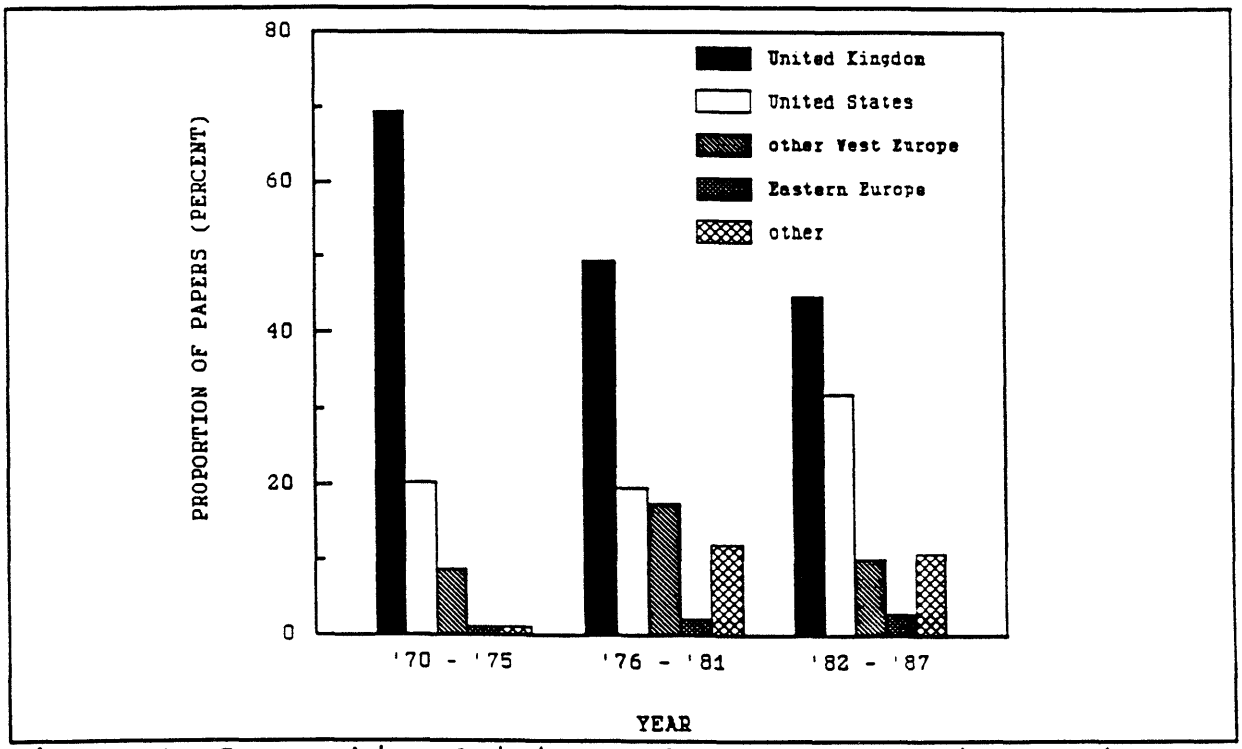

Figure 4 Geographic Origins of Papers Published in R&D Management 1970 to 1987.

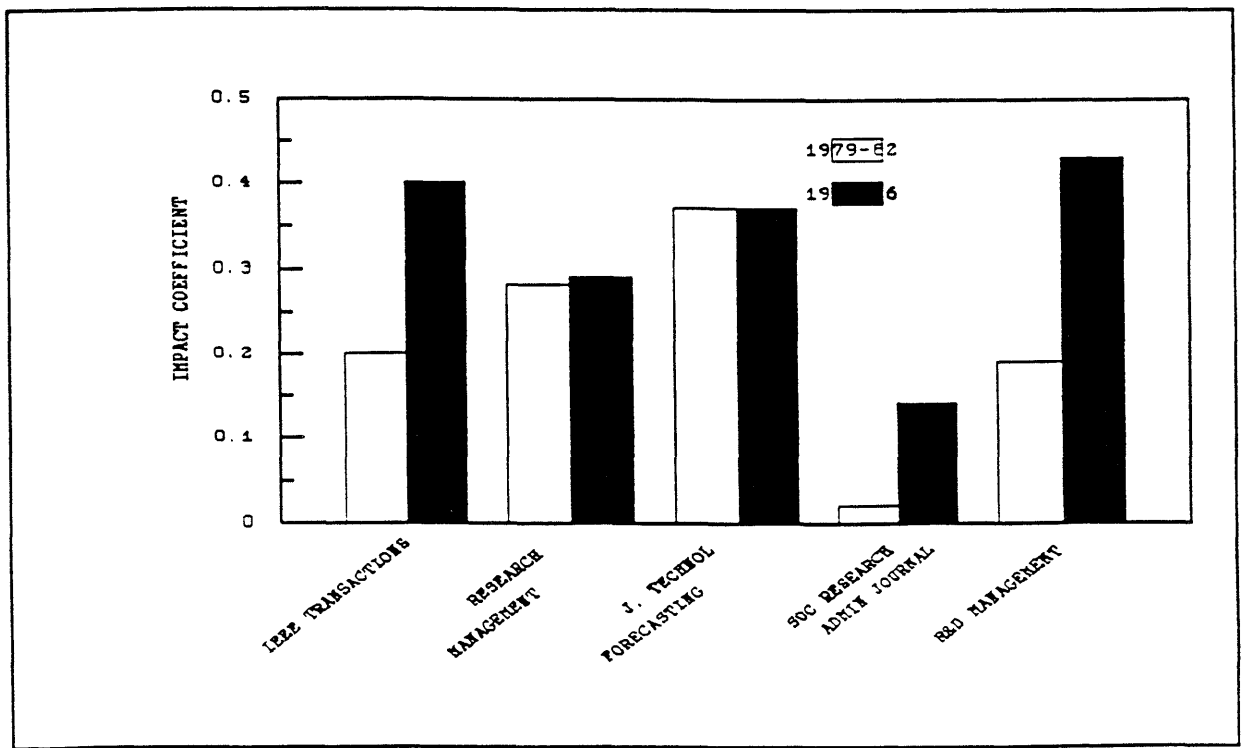

Figure 5 Impact of Papers in the Principal Management of Technology Journals as a Function of Time.

that of "journal impact." This is measured in terms of the degree to which the articles in all journals in a given year cite articles published in a given journal in the two preceding two years. In a sense, it is an indicator of the extent that articles in a given journal are affecting the work of others. The most interesting observation concerning this statistic, for the journals in our field, is that it has increased remarkably in the past four years (Figure 5). As a research field, R&D management, or management of technology (the broader term by which it has now come to be known) has definitely arrived. We are beginning to receive the recognition which we have long sought. It is now up to us to produce outstanding research in response to this recognition. If the index is any true indicator of "impact," we still have some distance to cover. In other areas of management research, the magnitude often exceeds one.

DYNAMICS OF THE FIELD

There is some indication that this is happening. The half-life of citations is one indicator of the dynamism of a research field. Using that indicator, we can see that our citations have a half-life of about six years (Figure 6). This compares very favorably with the half-lives reported for journals in other management disciplines (Figure 7).

Given that we are achieving the desired level of recognition and are producing at an exciting rate, where are we to go from

here?

FUTURE DIRECTIONS

As empiricists who must necessarily rely on measurements no more advanced in time than the present, we are very uncomfortable in predicting the future. Fortunately, that task lies beyond what was asked for in this paper. There has recently been considerable discussion of future direction. Some of you have been parties to that discussion. We will merely draw on two documents to outline what others believe to be the important areas for future research.

The first of these documents was prepared by a panel

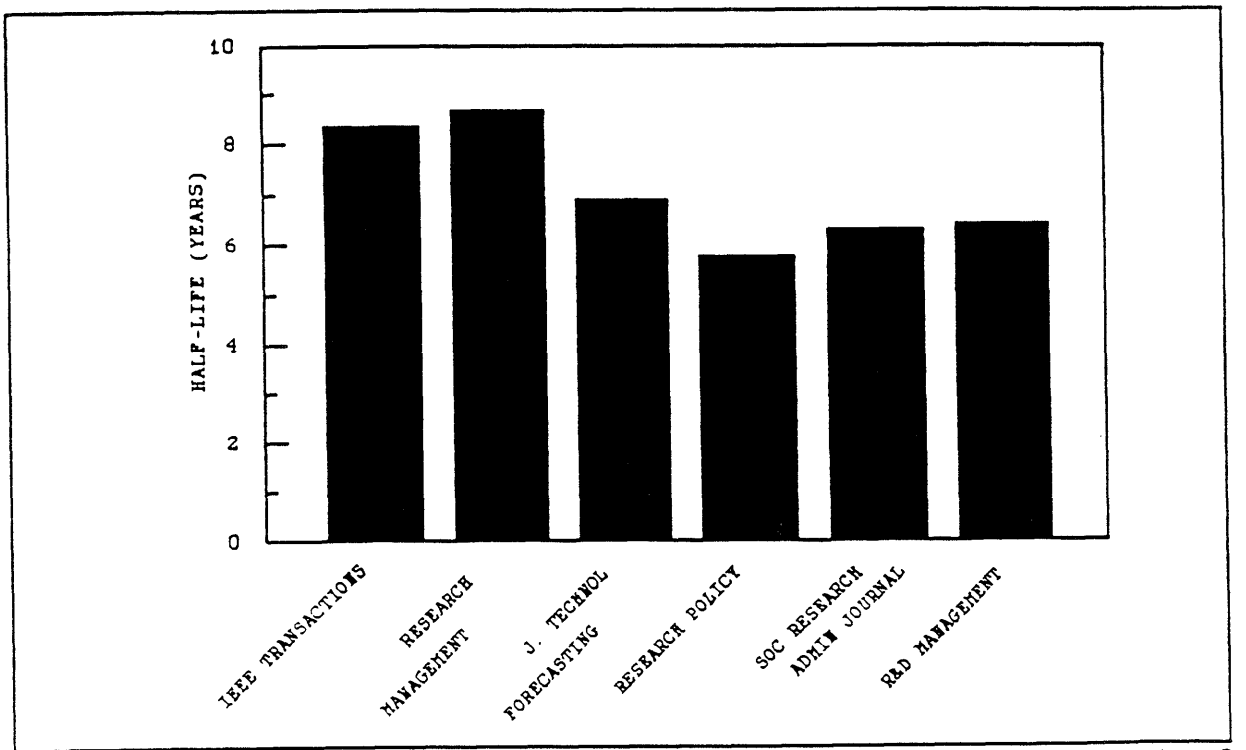

Figure 6 Half-life of Citations in the Principal Management of Technology Journals as a Function of Time.

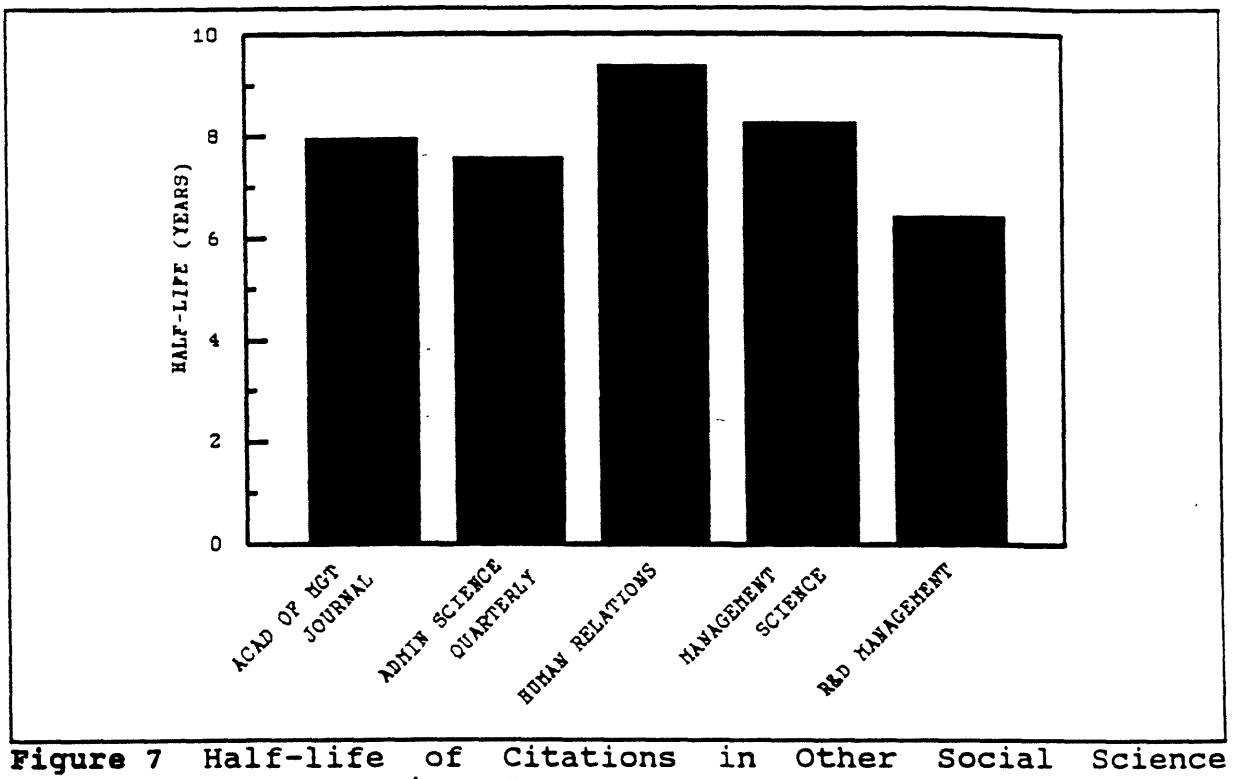

Figure 7 Half-life of Citations in Other Social Science Journals, for Comparison Purposes.

convened by the National Academy of Sciences/National Research Council in the United States. The second was prepared by the Public Affairs Council of the American Association of Engineering Societies. Both bodies comprised representatives of industry, government, and academia. The first group perhaps had better representation from among those in our "invisible college." The two reports have a considerable bias to them; nevertheless, their joint conclusions should be of interest to us all.

They point out ten specific managerial needs which can be used to define directions for our research (Table II). We will attempt to take a first step in that direction. Several of the expressed needs relate to well-established research areas.

Others open up new directions for exploration. Of course, since it is to a great degree a practitioner's "wish list," not all of the problems presented are tractable in terms of current research capabilities.

The integration of technology into corporate strategy is receiving a considerable amount of current research attention. It is one of the more active areas currently (as witnessed by the agenda of the TIMS conference mentioned earlier).

"Organizing for Technological Flexibility" is our interpretation of "how to get in and out of technologies faster and more effectively." A topic such as this calls for research in diverse areas ranging from cognitive psychology and group conformity to the nature of organizational change processes. It would be aided by research in designing organizational structures that would compensate for inflexibilities that exist at all of these levels.

Technology assessment, in the sense intended in this list, is principally concerned with evaluation in terms of potential benefit for the firm. It is directly in line with that long and difficult tradition devoted to project selection and evaluation.

Technology transfer is another well-established area of research. The committees merely call for greater emphasis on

internal transfer between design and manufacturing.

Table II Research Goals for Management of Technology.

- UNDERSTANDING THE ROLE OF TECHNOLOGY IN CORPORATE STRATEGY
- LEARNING HOW TO ORGANIZE FOR GREATER TECHNOLOGICAL FLEXIBILITY
- DEVELOPING METHODS FOR EVALUATING TECHNOLOGIES
- TECHNOLOGY TRANSFER
- UNDERSTANDING FACTORS LEADING TO REDUCED DEVELOPMENT TIME
- IMPROVED UNDERSTANDING OF MANAGEMENT OF LARGE, COMPLEX AND INTERDISCIPLINARY OR INTERORGANIZATIONAL PROJECTS
- MANAGING INTERNAL USE OF TECHNOLOGY
- INCREASING THE EFFECTIVENESS OF TECHNICAL PROFESSIONALS
- IMPROVED UNDERSTANDING OF CONDITIONS PROMOTING AND INHIBITING "INTRAPRENEURSHIP"
- IMPROVED UNDERSTANDING OF THE ROLR OF BASIC RESEARCH IN INDUSTRY

The reduction of product development time is perhaps the most critical current problem in the eyes of R&D managers. It is not at all clear what sorts of research will lead to solution of the problem, but it probably will involved a lot of us. Hopefully, we can be creative in defining tractable sub-problems and developing research strategies.

The management of large complex projects was addressed many years ago by the founder of our research group, Don Marquis. Don and others put a lot of effort into it in those days. Perhaps it is an area that needs to be resurrected and re-emphasized. It is an expensive topic. Gathering data on any reasonably sized sample requires a large amount of effort as well as considerable travel.

Managing the internal use of technology is a research area in which the authors have been considerably involved over the past four years. The "Management in the 1990s" research program at MIT has been directly concerned with the impact of one very important technology, information technology, on organizations. Several similar groups around the world are also looking at this same set of phenomena. What we as researchers need to do is to build links to these existing research activities. The introduction of microprocessor-based engineering work stations and greatly improved means of communication will have an enormous impact on the functioning of R&D organization, in fact, on the

very nature of scientific and engineering work.

The committees call for "leveraging the effectiveness of technical professionals." This is a broad charter and many of us have been involved in research related to this problem for many years. It includes studies of staffing, reward systems, group behavior, leadership and supervision, and organizational structure, at a minimum. In other words, it is a call to organizational behavior and human resources people to concern themselves more with this increasing component of organizational populations.

"Intrapreneurship" has received and continues to receive a great deal of attention from both researchers and practitioners. Our colleague, Ed Roberts, is clearly the leading expert on the subject (and will regret to his dying day the fact that it was someone else who invented such a creative title for the phenomenon). This is certainly a well-established area and the call is more for continuation than re-direction.

Finally, the AAES workshop called for "understanding the proper role and structure of basic research in industry." We would remove the final phrase and broaden the perspective. We need to better understand the role of basic research, where to locate it, its relation to technology, and how to structure relations among the organizations that are both producing it and

consuming its results. This requires a better understanding not only of internal organizational relations but of inter-organizational relationships as well. How can we improve the ways by which industry, university, and government laboratories relate to each other? An entire range of interesting research problems are opened by this question. It will keep a lot of us busy for a long time.

CONCLUSIONS

Well, there it is. A rough outline of where we've been and an ever rougher outline of where we should be heading. The important point, however, is that society is now looking to us to produce. There is clearly a market for our research results, and hopefully some recognition of the field within major business schools. It is time for us to get to work and produce at the level and quality that is expected of us.

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