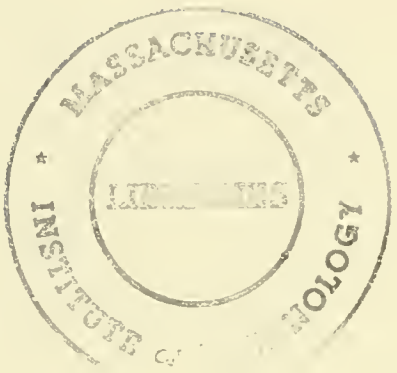
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THE MIT INTERNATIONAL AUTO RESEARCH PROGRAM

A STUDY OF UNIVERSITY-INDUSTRY RESEARCH PARTNERSHIP

VANDANA UPADHYAY

AUGUST, 92 3548-93

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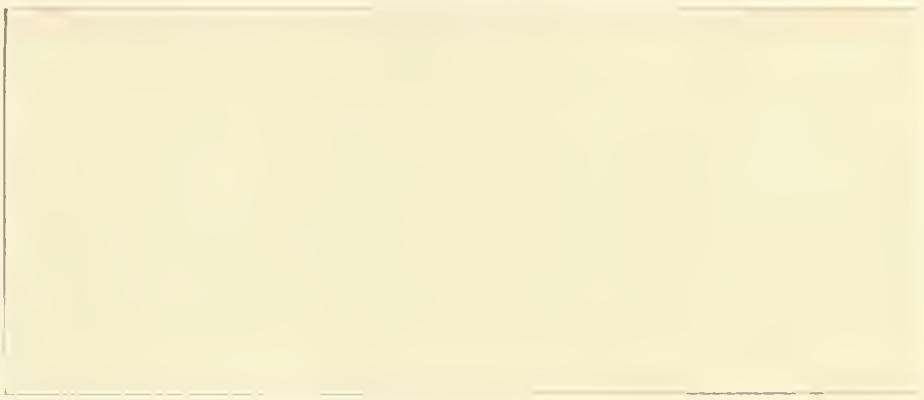

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The MIT International Auto Research Program

A Study of University-Industry Research Partnership

August 1992

WORKING DRAFT

By

Vandana Upadhyay

MOT '92

INDEX

<Author: I have revised the summary significantly to give what I think is a more thorough summary of the paper. Please review.>

Executive Summary

The MIT auto research program has set the standard for global industry studies. By involving numerous governments, firms, researchers, and stakeholders from all over the world, the program has produced an extensive, systemic body of knowledge that is of great use to the industry. In fact, as a result of the program, more is known about automobile production than about any other industry of comparable size and international importance.

The program's research methodology was revolutionary. It bridged the social science and technology disciplines by systemically studying the interaction between technology and people in industry. Thus, the program's broad range, usefulness to the industry, and innovative methodology make it an excellent model for other international research programs.

The two books that emerged from the program -- The Future of the Automobile and The Machine That Changed the World -- set an example for academic writing. They were readable and practice oriented, and they had a profound impact on auto industry executives, industry practitioners, and policy makers.

The industry accepted the program's findings, which were contrary to prevailing wisdom, because the books furnished empirical proof for concepts that journalists had described but not supported. The fact that these conclusions were drawn by academics who were perceived as impartial and free of any vested interest lent them substantial credibility.

The program's policy forums established an effective process for information exchange between university researchers and industry practitioners. They also promoted more meaningful dialogue among the representatives of government agencies, firms, union officials, and consumers.

The program has demonstrated that the university is the ideal setting for research projects that attempt to understand industrial activities as large-scale systems. No other agency has the access, networks, resources, expertise, and reputation for impartiality that a university has.

Further, the program has proved to have direct relevance to MIT's educational and research goals. For instance, graduate students who participated in the program are more conversant with real-world problems than others, and when they enter the industrial environment, they adapt to practice very quickly.

Despite the auto program's great successes, some areas for improvement remain. Confidentiality of company data remains a concern to sponsors. Some sponsors believed that identities were not effectively concealed in The Machine That Changed the World. They are concerned when the researchers go on to work for consulting firms or their competitors.

While the program has maintained a close working relationship with industry, it has not developed strong links with the academic community. More senior faculty need to be involved. The academic evaluation system needs to be reformed to reward participating researchers and faculty members. Program managers need to place more emphasis on publishing in scholarly journals. Academics should more actively work to disseminate the findings, not only to industry, but to business students as well. The translation of research findings into the curriculum remains a challenge.

And finally, the relationship between the university and industry must be finetuned. Guidelines must be developed for licensing or giving the byproducts of research -- analysis tools and computer programs -- to sponsors. It must be decided how far the university can go in helping companies implement suggestions without entering into a consulting relationship. University governance of research programs must be reviewed.

MIT's strengths are its leadership in technology education and research, its tremendous wealth of intellectual capital, and its tradition of working with industry on industrywide problems. It is well placed to develop more industry-sponsored research programs.

Introduction

To increase and diversify their funding sources, universities began entering into cooperative agreements with companies. Between 1978 and 1988, industry spending on university research and development (R&D) nearly tripled in real dollars. At the same time, nearly a hundred universities started research parks to encourage R&D companies to locate near their campuses.

However, conflicts emerged when industrial sponsors wanted to restrict the use of the research findings. Most universities gave sponsoring firms special access, agreed to limited publication delays, and revised their patent policies to encourage more patenting and licensing of their discoveries. The same ten-year period also saw a doubling of universities' share in patents awarded in the United States.

Critics inside and outside universities were alarmed by these developments and warned that increasing interaction with industry could damage universities by encouraging research with commercial applications instead of basic research, by restricting communication among scientists, and by creating conflicts of interest for faculty.

When these concerns first surfaced in the early 1980s, sufficient evidence was not available to draw conclusions. However, in 1992 it became plausible to examine some of these concerns. In the spring term, MIT began a faculty seminar on "The Changing Landscape of University-Industry Relations." MIT was an ideal setting for this investigation, given its long tradition of working with industry and its diverse industry-related programs, such as the Industrial Liaison Program, research centers focused on particular industries, and industry consortia.

The main objective of the seminar was to encourage faculty interest in university-industry relations. Each session featured presentations by MIT faculty and administrators who had had firsthand experience with industry-sponsored research. The seminar coordinators, Bernard Freiden, Robert McKersie, and Dan Roos, ultimately decided that a case study of MIT's International Motor Vehicle Program (IMVP) would be a useful exercise. The case study would analyze the program's evolution and record its contribution to and impact on the industry as well as MIT. They hoped that the case study would help MIT project administrators manage other industry programs.

The seminar coordinators chose the IMVP program for a number of reasons. The program's research agenda was unconventional in that it was not strictly confined to one discipline. Further, the program was not purely focused on science and technology nor on social science. Rather, it was a study of the application of

technology in a social system. The program did not seek to develop a product or technology but only know-how and knowledge. Moreover, the program is considered very successful and has earned considerable acclaim for MIT.

I arrived at MIT in 1991 to attend the Management of Technology program, which is conducted jointly by the business and engineering schools. Before joining this program, I worked in a telecommunications R&D institution in India in a number of functional areas including project management, product development, technology transfer, and business development. The seminar coordinators originally appointed me to report on the seminar proceedings and, when the seminar concluded, I was retained to conduct the case study.

The research methodology for the three-month project included a literature review, a study of correspondence and internal memos, and interviews with a number of individuals, including past and present program researchers, administrators of other industrial research programs, and faculty members who were planning to develop similar research initiatives.

First, I studied the history of university-industry research partnerships and the documents related to the IMVP program. Then I conducted the interviews, which were customized for each interviewee, depending on his or her current affiliation, association with the program, and organizational responsibilities. Next, I presented my findings to a group of faculty members and administrators, who assessed their accuracy and completeness. I used this feedback to prepare the final report, which was reviewed by researchers associated with the program and by Freiden, McKersie, and Roos.

A note on terminology is necessary. Two programs at MIT have studied the automobile industry, and a third program began in 1991. For the purposes of this report, these projects are treated as three phases of a single program: the MIT auto research program. I use the word "phase" to stress the evolutionary character of the research activities and their management. Comparisons are made between the first and second phases in order to highlight the extent of learning and improvement, not to imply that the first phase was not successful. On the contrary, without the groundwork laid by the first phase, the more visible and acclaimed second phase -- the IMVP -- could not have been conceived.

The body of the report consists of three sections. The first section describes the history of university-industry research partnerships, the genesis of the auto program, and each phase. The second section presents the findings regarding research management. The final section places the program in MIT's institutional context and evaluates its contribution.

I would like to thank all the faculty members, program researchers and administrators, and outside parties who helped with this report. In particular I would like to mention Professor John Paul MacDuffie, who was on the road this summer but still managed to call me from wherever he was to do phone interviews past midnight, and Dr. James Womack, who managed to find several hours for interviews even while putting the final touches on his book. Special thanks are due to Professor Bernard Freiden, who helped me identify issues of institutional relevance. Thanks to Professor Dan Roos, who gave me unrestricted access to all program documents and correspondence. Last but not least, I would like to thank Professor Robert McKersie for giving me the opportunity to work on an extremely interesting assignment and for his guidance in bringing this report to its final and vastly improved form.

Finally, I would like to submit that my effort was sincere and thorough given the limited time, and I hope I have been able to present an objective, informative, and insightful report.

<Author: I have eliminated the list of acronyms. Some of them are familiar enough that they don't need to be on a list (e.g., GM, TQM). Others strike me as too awkward to be used as acronyms (TFOTA, TMTCTW).>

I University-Industry Research Partnership

1.1 Fundamental Issues

The old model of industry-sponsored research was based on philanthropy and patronage. Until the 1970s, industry simply gave money to universities to expend as they saw fit. But securing such research funds has become much more difficult. Universities increasingly compete both with each other and with firm R&D departments for funding. Federal assistance for research has decreased. In addition, firms increasingly want to determine the research agenda and even to expect specific deliverables within a predetermined time frame. But it is difficult to promise specific deliverables, particularly in nascent areas where uncertainty is very high. And academics often feel that they should be free to engage in research of their own choosing, guided only by intellectual curiosity.

James D. Bruce, professor of electrical engineering and head of MIT's Industrial Liaison Program in 1983, has identified three key issues in a university-industry research partnership.

1. The research program's relevance to the essential missions of the university and participating firms

Universities and firms can work together only if their objectives are congruent. Collaborative research programs must balance the university's pursuit of research as an integral part of its educational activities and the industry's search for useful knowledge to be applied in the development of products, processes, and services.

2. Time frames

Universities and firms have different expectations regarding research time frames. Academics generally take a long-term view, whereas industry participants have immediate pressures they are hoping to address quickly. Programs must be organized to accommodate these different approaches.

3. Confidentiality versus openness

Universities traditionally treat research findings as public information, whereas companies want exclusive access to them. The challenge is to protect confidential firm information while allowing the university to fulfill its statutory and ethical requirements of serving the public good, creating an open atmosphere for research, and making results available for general distribution.

1.2 New Modes of R&D Cooperation

Business is beginning to recognize the benefits of cooperation in an environment complicated by rapid technological change, global competition, and increased regulatory and consumer pressure for environment protection, user safety, and energy conservation. A new paradigm for R&D cooperation among universities, industry, and government is needed.

Cooperative R&D seems to be the only effective institutional arrangement for government-mandated innovation (e.g., fuel efficiency, passenger safety, and emission control) and generic technologies, which are intermediate technologies that are neither basic nor applied. Generic technologies are complex and multidisciplinary; they require large-scale facilities. They also are easy to appropriate and are unlikely to remain secret as companies enter joint ventures and employees change employers. The research on generic technologies organizes fundamental scientific and engineering principles into conceptual models from which product or process applications are derived. The research results are thus applicable across a range of products regardless of make or model. The research done in the International Motor Vehicle Program (IMVP) that emphasized the interaction between technology and personnel belongs to this category.

<Author: I would delete the following sentence. Doesn't seem pertinent here. "But universities face stiff competition from federal labs, not-for-profits, and industry consortia as alternative auspices for such research.">

1.3 Climate for Cooperation

<Author: Originally you stated that 4 factors have caused the spate of cooperative research initiatives. But 2 of the factors are specific to the automotive industry and therefore can't be the cause of cooperative research programs in general. I've rewritten this section accordingly.>

Four factors have directly or indirectly encouraged cooperation among automotive companies. Two of these factors affect U.S. industry generally and can be credited with stimulating the recent spate of cooperative research initiatives in other industries.

1.3.1 Legislation

A decade ago in the United States, four key legislative actions promoted R&D cooperation among firms in the same industry. These were the Steven-Wydler Innovation Act of 1980, the Economic Recovery Tax Act of 1981, the National Cooperative Research Act of 1982, and the Small Business Innovation Development Act of 1982.

The direct impact of these enactments on industry

participation in the auto research program is unclear, but they undoubtedly eliminated certain perceived barriers to collective R&D. Also, the relaxation of anti-trust legislation with respect to cooperative R&D made it easier for companies to collaborate.

1.3.2 Change in Corporate Culture

The 1980s saw a sea change in U.S. corporate culture as businesses took a new, positive attitude toward learning from others. Business leaders perceived that U.S. competitiveness had declined and that cooperative government-industry policies in Europe and Japan were giving those countries a competitive edge. Japanese competition, in particular, catalyzed this transformation.

Recently, U.S. companies have made considerable investments in improving quality and benchmarking best practice. They are not as averse to sharing their operational knowledge with each other. The Total Quality Management (TQM) movement and the Malcolm Baldrige National Quality Award have enhanced this atmosphere of cooperation. Thus the drive to improve performance has led to a true management revolution in corporate America.

As a consequence, the boundaries between a company and the rest of the world, between internal and external, have broken down. The IMVP, which was based on extensive information sharing regarding performance, productivity, and quality among companies that were keen competitors in the marketplace, could succeed only in such an environment.

1.3.3 Automotive Industry Characteristics

Although consortium R&D is not new to either universities or industry, what is unique about the MIT auto research program is that it represents the participation of the entire world car industry. The automotive industry is highly concentrated, not only in terms of manufacturing capacity but also in terms of product characteristics. To illustrate, there are some two hundred large chemical companies in the world with a very wide range of products. In comparison, there are only about a dozen major car assemblers in the world and, until the last decade, the automotive industry was concentrated in a few countries. The United States has the largest manufacturing capacity in the world, the result of a large domestic market, and only three car companies: Chrysler Corporation, Ford Motor Company, and General Motors Corporation (GM). In Europe, only a few of the major economic countries have a national car manufacturer, and Japan emerged as a global competitor in the industry only in the 1970s.

1.3.4 New Challenges Facing the Industry

The golden years of the U.S. automobile industry ended with

the 1960s. In the 1970s, for the first time in history, the industry faced such harsh challenges that many predicted it would undergo fundamental change. The causes of the downturn included increasing competition, economic recession, energy shock, traffic congestion, and new passenger safety and environment compliance requirements. Industry managers realized that overcoming these challenges far exceeded the capability of any one manufacturer and that, to survive, the industry would have to cooperate.

II MIT Auto Research Program

2.1 Genesis

In 1978, when civil engineering professor Dan Roos became director of the Center for Transportation Studies, he considered initiating a large-scale multidisciplinary research program that would involve faculty from engineering, social science, and management. After several discussions with other MIT faculty and with the chairman of the German Marshall Fund, Roos had almost settled on a project that would involve the auto industry. It is important to note that MIT has had a long association with U.S. auto companies and that GM has been funding research at MIT for over two decades.

<Author: I'm assuming that Altshuler's project was CARP, although this is unclear originally.>

At about the same time, an earlier MIT research project, which had started in 1975 with a grant from the U.S. Department of Transportation, was coming to an end. The Cooperative Automotive Research Program, headed by political science professor Alan Altshuler, had studied problems in the U.S. transportation sector, including mass transportation systems. The result of the study was the book Urban Transportation Systems. Although this program ended, a number of problems remained to be studied, such as air pollution, energy consumption, safety, and mobility for those without vehicles. At that time, U.S. automakers were still looking to the Department of Transportation to define a new R&D policy. With the end of this program, there was an internal market for the new one.

Roos, who had worked with Altshuler before, asked him to be codirector of the new program. Together they tried to set a research agenda for the industry, convinced that there was enormous potential in untapped technology to dramatically improve the motor-vehicle-dominated transport system on practically every dimension. They wondered if the automobile industry would be able to rise to the challenge.

At that time, the U.S. car industry was in trouble. Higher interest rates had suppressed the demand for durable goods, and the rising dollar made Japanese imports cheaper. One of the giants of the industry, Chrysler, was bailed out by the government. Roos and Altshuler thought it would be interesting to study why German and Japanese auto companies were thriving and U.S. companies were not. Specifically, they wanted to study how an industry responds to changing technology, increasing competition, and regulatory pressure. Thus began a research project that was somewhat ambiguous in scope and intent.

2.2 First Phase 1979-1984

2.2.1 Program Objectives

The first phase of the auto research program was a four-year study of the auto industry in seven countries: France, Italy, Sweden, the United Kingdom, West Germany, Japan, and the United States. The German Marshall Fund of the United States provided a major grant to MIT in November 1979 for program initiation. In February 1980, additional funding came from the U.S. Department of Transportation to investigate institutional factors shaping U.S. industrial policy. In March 1981, the Eli Lilly Endowment, Inc., provided major grants to both MIT and Purdue University for collaborative research on the future of the automobile. Both private and public sponsors gave additional grants for general program support and for specific research topics. Country research teams were likewise funded by national sponsors that included governments, foundations, and auto manufacturers.

The first phase started as an informal, decentralized, international research project involving over a hundred people from industry, labor, government, academia, and research institutions in Western Europe, Japan, and North America. The program's principal objectives were as follows:

1. To understand, compare, and appraise experiences among countries with respect to policies that have had a major influence on the production, use, and character of the automobile;

2. To identify and appraise the major automobile policy issues that are likely to be significant from 1980 to 2000; and

3. To report the research results and widely publicize the program's principal policy findings and conclusions.

2.2.1.1 Research Agenda

To achieve the first two objectives, the research agenda was organized into four principal research areas:

1. Government policy making and implementation;

2. Industry structure, corporate strategy, and labor relations;

3. Technological opportunities and uncertainties; and

4. Automobile usage strategies.

2.2.1.2 Policy Forums

The third principal objective of the program, to diffuse the

research results, was to be achieved through policy forums. Senior members of the program would come together once a year to discuss key national and international policy issues. The forums complemented and supported the main research program.

2.2.2 Research Organization

The project was organized as follows:

1. Program Directors

Altshuler and Roos, as codirectors, provided the executive leadership for all aspects of the program and served as leaders of the U.S. research team.

2. Country Team Research Leaders

Each country research team had a leader. These senior researchers organized and coordinated research in their countries, prepared national reports, and attended the policy forums.

3. Associates

The organizations that participated in the program appointed associates to represent their interests. These associates kept the research program and their nominating organizations linked between policy forums. They attended the forums as observers and participated in both research meetings and country team meetings. They were also expected to take an active role in monitoring and reviewing the research program.

4. Researchers

The researchers were independent scholars who worked under the general guidance of the directors and the country team leaders. They participated in the general research meetings and attended the country team meetings. Although only a limited number of researchers from each country were invited to attend the forums, the researchers were free to meet among themselves in smaller groups.

5. The Secretariat

The secretariat consisted of administrative staff members who acted as liaisons among the national research teams. They coordinated policy forum logistics and distributed all reports and research papers.

Thus, in this phase, the management and funding of the research teams were decentralized. The national teams raised funds for their activities and determined their own research

agendas while adhering to the program's principal objectives. At the end of the program, the directors realized that this was not an effective way to manage an international project. The national teams did not interact much, and researchers did not ensure that their research agendas were congruent with program objectives. There was a lack of focus and of integration between research areas. James Womack, <Author: Please identify his role>, commented, "From my perspective there was a lot of Brownian motion from many of the team leaders, in particular the French, the Swedish, and the Italian." As a result, the quality of research was uneven in many areas.

The most prominent research product of this phase, the book The Future of the Automobile, had very little input from the researchers whose work was not consistent with the original research agenda. Therefore, many of the field research findings did not provide any meaningful conclusions.

Despite its shortcomings, the book was a success and as of this date remains the best-selling book published by the MIT Press. Its most important contribution, from the perspective of the program directors, was that it convinced the industry that academics were capable of conducting research that would be of relevance to the industry. This led to the conception of the second phase, the International Motor Vehicle Program.

2.3 Second Phase (1985-1990)

Some industry patrons, impressed with the outcome of the first phase, encouraged Roos to continue research on the auto industry. One person in particular promised a million dollars in seed funding on behalf of certain automakers. With this assurance, Roos and two colleagues traveled around the world in the fall of 1984 to encourage participation and funding. Two other individuals helped win the confidence of European automakers who were not happy with the conclusions drawn in the previous program. <Author: Is it necessary for these people to be anonymous? If not, identify them.>

Funding support came from several sources, including manufacturers; trade associations, such as the Motor and Equipment Manufacturers Association (MEMA) and the Japanese Automotive Parts Industries Association (JAPIA); three parts suppliers; and several governments from North America and Western Europe. This time the concept of national teams was discarded, and funding from all sponsors was put in a common pool, which funded those research proposals that addressed the scope and overall objectives of the program. This change, along with some research streamlining, helped neutralize the country and researcher bias that had crept into the earlier study. It also helped eliminate the capacity of any one sponsor to bear pressure on a country research group.

2.3.1 Research Agenda

In contrast to the first phase, the IMVP's research areas were well defined at the onset.

1. The development process for products and processes -- adoption of new technologies, design and engineering processes, and product definition in an age of segmentation.

2. Manufacturing practice -- how assembly plants and engine and transmission plants differ in terms of human effort, tools, and inventories consumed and the quality and volume of products produced.

3. Suppliers -- the options for organizing a manufacturing process involving a final assembler and a host of suppliers of components, process machinery, and raw materials.

4. Human resources -- the impact of work organization and human resource management, particularly training, on job satisfaction and productivity.

5. Distribution -- how distribution systems vary among regions and the implications of new technologies for distribution, manufacturing, and product development.

6. The international system -- the rules of trade and investment with special reference to management of the looming capacity crisis, accommodation of new players, and the process by which best practice is diffused across the world.

2.3.2 Research Organization

The six research areas were to be compared with each other and cross-nationally. They were further divided into two or three research tasks, which were assigned to research teams or, rarely, to a single investigator. A team usually consisted of two or three faculty members or research associates. Graduate students who assisted in the research tasks were called research affiliates.

The administrators had learned from the first phase that a loose coupling of national teams had been ineffective. Yet cultural differences, communication barriers, and the geographical dispersion of researchers made it neither feasible nor desirable to have a large central staff to coordinate the project. The organization of the project was a challenge.

It was decided that there would be only one overall director, Roos, supported by a director of European research, Dan Jones, and a research director, Womack. The research director coordinated and linked the research area coordinators, who were

each responsible for one of the six principal research areas and who presented results at the policy forums. In keeping with the international character of the research, three Europeans, two Americans, and one Japanese were designated as research area coordinators.

It is interesting to note that the ratio of research coordinators to regions (Europe, North America, and Japan) was the same in the second phase as in the first. But now the coordinators were responsible for a research area and not a geographic region; the IMVP did not split along regional or national interests as the first phase had. The research design also helped. The comparative analyses prevented the research from becoming focused on a particular region or country.

To handle logistics and coordination problems, the administrators encouraged key researchers and researchers from the new entrant countries (e.g., Brazil, Mexico, China, and Korea) to work at MIT. This served two purposes. First, the researchers from new entrant countries would improve the program's contact with their domestic research colleagues. <Author: Is this what you meant by "would be able to provide better continuing liaison with their domestic research colleagues"?> Second, the core staff would not have to travel as much, thus saving the program money and better utilizing core staff time.

The second phase concluded with publication of The Machine That Changed the World. The book identified the best practice in several areas of auto manufacturing, based on the most comprehensive international study of any industry ever undertaken. It demolished the myths that labor costs, culture, and government policies are critical elements of competition. The research showed that advanced technology had played only a modest role in the success of companies engaged in lean production, and it highlighted the role of workers for the first time. The book revealed that the Japanese treat workers as solutions to problems whereas Westerners treat them as problems. Low productivity in U.S. and European plants was not due to the inferiority of their blue-collar workers, and the superiority of Japanese companies stemmed not from fancy technology or a better labor force but from their organization and implementation philosophies.

The book was translated into a number of languages, including German, Swedish, Danish, Portuguese, Spanish, French, and Japanese. It has sold over a hundred thousand copies in its English edition, and in Germany, with over 43,000 copies sold so far, it has remained on the nonfiction best-seller list for several months.

The research findings had a profound effect on industry practice. Many auto companies restructured their organizations in

response. Several industry stalwarts concede that the book had a tremendous impact on industry executives. The chairman of one of the largest European auto companies introduced two IMVP researchers, who were invited by his company to give a talk on the program findings, by saying, "Gentlemen, the life or death of this company depends on how seriously you take what these people have to say in the next half hour." <Author: This isn't a tremendously convincing quote; people often exaggerate when they introduce speakers. Do you have a better one?>

2.4 Third Phase 1991-1994

The third phase of the MIT auto research program is concerned with the transition to lean production and its implications. The program focuses on four fundamental issues:

1. Best practice. The research on best practice in manufacturing and product development done during the IMVP is being extended to other functional areas, including suppliers and distribution, and to the study of changes over time.

2. Environmental issues. The second research concern is how the lean system can help address competitive and environmental issues at the same time.

3. New opportunities. This area will study the potential applications of new technologies, such as the Intelligent Vehicle Highway System, that could have a significant impact on automobile usage.

4. Organizational transition from mass to lean. The researchers will investigate the implementation of best practice and how new processes and technologies are being applied in three organizational contexts: the traditional Big Three factory, the transplants, and new types of organizations such as the GM Saturn Project.

The Sloan Foundation has provided a major grant to the program to conduct a long-term study of the competitive position of U.S. auto companies relative to other car manufacturers, including their principal problems and concerns and the process of implementation of best practice. This could cause concern that the program will benefit U.S. companies at the expense of other manufacturers, but the current program director thinks this is not an issue, and the level of industry participation does not indicate any concern.

Program organization is still evolving, and the program does not yet have a research director who can coordinate and monitor the program on a day-to-day basis.

Overall, the program managers face a mammoth challenge in

the third phase because the past success has raised sponsors' expectations. Performing a brilliant encore to the IMVP and its enormously successful book is not impossible, but it will not be easy.

Table 1 summarizes the differences in the three phases. <Author: I suggest placing this sentence here rather than at the beginning of the next section, where the emphasis is on phases 1 and 2.>

Table 1 : Overview of MIT Auto Program

	Phase I	Phase II (IMVP)	Phase III
Duration	1979-1984	1985-1990	1991-1994
Budget (US$)	1.5 million	5.0 million	4.5 million
Countries	4	13	13
Researchers	130	54	NA
Sponsors	3 major sponsors: DOT, Marshall Fund, Eli Lilly Foundation	36, majority of them corporate	Sloan Foundation, some corporate sponsors
Research Focus	Industry structure Government policies Automobile use strategies	Best practice in manufacturing and product development	Best practice over time Transition to lean production Environmental issues

III Program Management

3.1 Learning Process

The first phase was a learning experience for the managers and researchers who continued to be associated with the program. They made a number of management changes in the second phase:

1. Number of researchers

The first phase had an unmanageable 130 researchers spread over four countries and many different institutions. The second phase would be even more widespread, involving thirteen countries. To maintain control, the number of researchers in the second program was cut to less than half.

2. Research management

In the second phase, the research agenda was determined at the very beginning, the project was more focused, and research areas were better integrated. Instead of splitting along country lines, the research findings from all countries were compared. Also, the research teams in the second phase were coordinated instead of decentralized.

3. Interaction among researchers

Although policy forums and research meetings gave researchers an opportunity to interact with each other and the industry participants, these mechanisms were not adequate for idea exchange. More travel was not feasible, considering the time and money involved. Instead, foreign researchers came to MIT as visiting scholars or scholars-in-residence. The day-to-day interaction proved very useful as researchers had the opportunity to look at problems from new perspectives. Thus, the competing biases or disciplinary inclinations of researchers that tended to threaten a systemic study were ameliorated.

4. Funding

When the national teams were left to raise funds on their own, they were not able to adhere strictly to the research agenda, and local sponsors sometimes pressured them to pursue research that was not directly relevant to the program. In the second phase, all funding was raised centrally, by the program managers, and put in a common pool.

Two other steps helped eliminate sponsor pressures. The contribution from any one organization was limited to a maximum of five percent of the total program funding. Further, equal amounts were raised from the three geographical regions so that no one region could be seen as overly powerful.

5. Communication

In the IMVP, sincere effort was made to improve communication between researchers and sponsors. The annual policy forums were still rotated among regions, but now the papers to be presented were sent two or three weeks in advance, giving the sponsors enough time to understand the results and thus to convey their feedback in an interactive setting in real time. A quarterly newsletter on research activities was also started.

3.2 Organization Structure and Management Tasks

There does not seem to be an ideal organization model for these research programs. As temporary organizations, they are flexible enough that the structure need not be designed. It can evolve around key people and fall into place as researchers come together. In the first phase, the codirectorship provided the program with intellectual leadership, liaison skills, and outreach. The second phase arrangement was also successful.

However, the program managers should be able, collectively, to address certain key tasks. How those tasks are allocated will vary depending on experience, capability, and availability.

Key Management Tasks	Program Managers' Qualities
Intellectual Leadership	Respected authority in a field but not narrowly bound by a particular field or discipline; intimate knowledge of the industry.
Project Management/Cross-Functional Coordination	Intellectual interest in the project; ability to combine research perspectives and forge alliances between researchers from different disciplines.
Communication ensure	Effective communicator; ability to intercommunication between researchers and sponsors.
Conflict Management	Ability to interact with industry people as well as academics; liaison or negotiation savvy.

The program's success hinges on its leaders. They need to be able to harmonize diverse interests, forge consensual agreements, and resolve conflicts as they emerge.

3.3 People Management

1. Handling different ideological and disciplinary perspectives

Researchers, by virtue of being academics, have different ideological leanings and disciplinary inclinations that sometimes influence the interpretation of research findings. As a result, synthesized conclusions do not always engender agreement among the individual researchers. Many times field researchers disagree with the principal researchers' interpretations. However, programs that are based on a systems approach may have less of a problem with this, given that the field researchers must take a systemic approach too.

2. Addressing nationalism <Author: "Nationalism vs. national interest" doesn't seem to accurately convey what this point is about.>

The first phase suffered from the tendency of national teams project national interests rather than to do objective assessments. In the second phase, all subject area reports were placed under the direction of foreign researchers. As each subject area involved a cross-country comparison, it was hard for any one subject area researcher to do more than present the actual situation. There was no way researchers could collude to get certain project results.

3. Getting researchers to work together

Researchers are used to working alone or, at most, as a team of two investigators. Making people feel that they are an integral part of a research process and that joint gains will be achieved in proportion to the level of group participation require considerable effort on the part of program managers. Researchers often disagree over methodologies and interpretations of results, and it is easy for people to feel sidelined or marginalized. A strong intellectual leader can help a program avoid many of these problems.

4. Achieving common objectives

Any research program has two customers: industry sponsors and academics. It is a tough task to satisfy both. Academics are pursuing careers as well as knowledge. Industry sponsors expect that as funders they have a higher claim. If program managers recognize potential conflicts early and take steps to handle them, they can avoid diversions from the program's overall goals. Congruence among the goals of the program, the researchers, and the sponsors is very important for the program's continued success. <Author: I added sponsors to this sentence. Ok?>

5. Continuity versus new faces

New researchers bring fresh perspectives to a program, but continuity is also important. The auto program has been fortunate in being able to maintain continuity, particularly in leadership. Womack, Jones, and Roos worked on the first and second phases; John Paul MacDuffie, Susan Helper, Stephen Graves, Jones, and Roos worked on the second and third phases, among others. <Author: Please verify first names of Helper and Graves.> It is always an organizational challenge to replace good researchers who have acquired an indepth understanding of the industry.

6. Disengagement

Recruiting researchers is easy compared to dropping those who no longer serve the program's needs. Friendships develop, sometimes between researchers and sponsors, and these create pressure to retain people. It requires excellent interpersonal skills on the part of the program administrator to disengage such researchers sensitively and acceptably.

3.4 Communication

The auto program's success can be attributed to a fair degree to the effective communication that was established among researchers, sponsors, and other interest groups. The program used a number of tools to address different communication needs. As discussed before, policy forums were an important and effective means of networking and receiving feedback. Researcher meetings, company visits, tutorials for suppliers, newsletters, and article publication were other means of communication.

1. Meetings Management

Meetings seem to be a key communication tool for an activity that is collaborative, multicultural, and geographically dispersed and that involves divergent constituencies. Meetings are not just for getting researchers to exchange information; they are also for encouraging communication between sponsors and program managers. To make these exchanges meaningful, program managers must do a considerable amount of preparation.

For example, before every policy forum the researchers and program administrators met to review the research program. They would decide what papers to present and to what extent to reveal intermediate results. Sometimes the decisions would be consensual, but if differences of opinion arose, program administrators would arbitrate and sometimes even force a decision on the researchers. Other meeting preparation included setting goals and identifying desirable outcomes.

2. Networking

The program, particularly in the policy forums, gave industry people from all over the world an opportunity to

interact informally and exchange views in a neutral setting. The intent was to bring together decision makers and academics and thus unite research findings with real-world policy planning. Although the forums by their nature encouraged this interaction, the program administrators also consciously worked to get those interest groups that did not actively seek participation in the auto research program to attend the forums. For instance, suppliers were invited so that they could have a firsthand opportunity to understand the issues affecting their customers.

3.5 Information Collection and Management

The university's neutrality puts it in a unique situation to do competitive and industrywide studies. All associated researchers and program managers must maintain this neutral position.

3.5.1 Researchers as Gatekeepers

In a research program involving multiple clients that compete with each other in the marketplace, the researchers must be perceived as neutral. The auto program has so far succeeded in maintaining objectivity. Although many sponsors did not like the findings reported in The Machine That Changed the World, none has complained of any bias in it.

To maintain impartiality and integrity, researchers must be gatekeepers. They must not allow themselves to be misled or coopted by a particular sponsor. In a few instances, researchers in the IMVP were asked to reveal information prematurely, but they were able to extricate themselves from the situations.

MacDuffie, an IMVP researcher, recalled that a few times he was asked to reveal information about a competitor. Once the officials of a sponsor company told him that if he disclosed what a rival company was doing, they would share what they were doing in their own plant. MacDuffie asked them to consider what would happen if he were asked to do the same by their competitors. Womack recalled his plant visits: "To avoid such a situation, for two years, the moment I entered an assembly plant and before someone told us anything, I would raise my hand and say, 'Please do not tell me anything that is secret.'"

3.5.2 Data Presentation and Protection

Sponsor companies are willing to go only so far in disclosing results. In the IMVP, sponsors encouraged the researchers to tell them about their poor performance so they could take corrective action. But they wanted researchers to reveal only the positive findings in public and to avoid, or at least downplay, the bad news.

Even when companies are disguised or multiple company data is aggregated, sponsors may be unhappy. When the findings from the IMVP were published in The Machine That Changed the World, the company identities were not effectively concealed. <Author: Do the authors of the book agree that the identities weren't concealed? It would be useful to say either: "sponsors did not believe that identities were effectively concealed" or "sponsors complained that identities were not effectively concealed, and the authors later conceded that they had made some mistakes."> Sponsors felt that even when data was grouped by continent, anyone could decipher the actual identities. Their feeling that the IMVP's confidentiality pledge was not honored has had a negative effect on the third phase. Sponsors seem averse to any national or regional comparisons, although they find such analysis extremely useful.

3.5.3 Access to Sponsor Facilities and Information

At the beginning of the second phase, companies did not know how their assembly plant data would be used, interpreted, or distributed. They also did not understand the full implications of the confidentiality pledge until intermediate results were presented. But once they started giving data, it was hard to disengage from the program and most of them went along.

However, not all companies were equally forthcoming about sharing data. For example, Ford shared its productivity data only up to 1987 because the initial conclusions of the assembly plant survey revealed that Ford was ahead in performance. It saw no need to give further data.

Although the Japanese were quite open, the U.S. companies stonewalled efforts to observe their operations. The European companies also initially rejected the idea of plant visits and studies. The program directors did a lot of convincing to finally gain access to their plants, but even then the Europeans were extremely reluctant to share actual data.

Of course, researchers can only appeal to companies to share data; they cannot force sponsors to do so. Researchers can try to motivate the sponsors by emphasizing the positive outcomes, but companies may feel they gain more by learning about other companies without disclosing their own operations.

3.5.4 Ethical Issues

Most ethical problems relate to information access and confidentiality, as described above. <Author: I deleted the information in this paragraph on the problems of doing continued research after a breach of confidentiality because that is covered in section 3.5.2.> Another ethics issue that concerns sponsors is the employment of researchers after the program ends.

As long as the researchers continue academic careers, sponsors are not concerned. But when the researchers take jobs with consulting firms or competitors, sponsors are naturally afraid that researchers could use the information in ways that may hurt them. A couple of researchers have joined consulting agencies while continuing to work with the research program. I do not mean to question their integrity, but such arrangements leave room for considerable misunderstanding.

Individual researchers have devised ways to avoid such conflicts. John Krafcik, who was a key researcher in the assembly plant study, is now working for Ford. When asked if this did not violate the confidentiality pledge, he said:

> I have avoided violating my confidentiality pledge by choosing to work in product development and not manufacturing, which was my research area. Before joining the organization I made it clear that I should not be under any pressure to disclose confidential information regarding other competitors. My employer has stuck to this promise, and in the three years I have been with the company,the promise has been kept.

3.6 Sponsor Management

3.6.1 Sustaining Sponsor Interest

Once a company has learned that its performance is world class, there is little incentive to continue participating in the program. This is a major issue for Ford and Toyota in the third phase. Many other sponsors are also not sure about the third phases's usefulness. To sustain sponsor interest, program leaders have to be creative in bringing new problems to the attention of the sponsors. They need to rejuvenate the research agenda by attending to previously uncovered areas.

In addition, the fact that the Sloan Foundation has given a large grant to the program might lead U.S. sponsor companies to think they need not contribute. This could negatively affect program dynamics because lack of financial commitment may mean a lack of information sharing. One of the researchers explained how the program may address this problem:

> We are prepared to say that although last time you did not give us all the data we wanted, still we gave you full feedback. But this time, unless you participate fully, you will only have access to research papers, since those are public documents. But do not expect any specific feedback or analysis of your operations.

3.6.2 Keeping Sponsors Satisfied and Expectant

The program's relationship with sponsors has not been consistent. Some sponsors have said that it will be tough for the program director to reconcile the different interests in the third phase. But they are confident he will be able to do so.

Most sponsors agree that the IMVP research was a good blend of academic and practical approach and that it stimulated awareness of the important issues. But they also think that the program focused on current problems and not enough on the long term. One researcher responded to this complaint by saying:

> Contrary to industry expectations that the university researchers should guide them to the future, academic researchers are not equipped to do that. . . . Actually academic learning lags behind industrial reality. . . . The most academicians can do is to provide snapshots of recent phenomena.

<Author: This paragraph doesn't fit here under Sponsor Management. Is there a better place?> Labor leaders want more balance between technology issues and social and personnel factors. They also expect academics to help them identify areas for improvement and to train them to implement changes and improve performance.

3.6.3 Company Gatekeepers

For the second phase, every sponsor organization nominated a liaison to interact with researchers and participate in policy forums. The liaison performed three functions: 1) conveying the sponsor's research concerns to the researchers and other participants through forums; 2) helping researchers gain access to the sponsoring company's information, employees, and facilities; and 3) conveying research findings to the sponsor and finding people within the company who could use the knowledge. The infusion of research results into organizational practice to a great extent depended on this person's enthusiasm and effectiveness. It also depended on the clout the liaison had within his or her organization.

The gatekeeper's functional background and work experience also influenced organizational learning. For instance, labor leaders feel that one reason human resource issues did not get much attention was that most of the company representatives were engineers, who typically do not understand people management issues.

3.6.4 Future of the Relationship

It is safe to say, given the example of the auto research program, that industry-university research programs funded mostly by industry, where the university acts as research contractor or

program coordinator, seem to be the most promising mode of precommercial R&D research when no single firm can do the research on its own. Of course, one reason for heavy industry funding is that government funding is shrinking. But industry funding also has the positive effect of generating a high degree of interest, involvement, and commitment to the research on the part of sponsors. Some government support is certainly essential because it provides legitimacy and balance. Academics could become beholden to the companies without it. Therefore, some participation, not necessarily just in financial terms, by either government agencies or other nonpartisan sources like foundations is important.

Once an industry program becomes highly visible, it is hard for companies to stay uninvolved. They join and stay with the program in order to have their say and to exert influence on research questions, priorities, and interpretation of results.

As for foreign firms, they must be included in order to find the best solution with global relevance. The problems currently being addressed in the auto program are truly global, and if research is precommercial, it does not result in an overwhelming competitive advantage for a company, country, or region.

4.1 Research Agenda

4.1.1 Motives for Cooperation

Apart from the stated objective of finding solutions to industrywide problems, many participants have hidden motives for participating. In the IMVP, the participating companies typically knew their competitors' statistics but wanted to learn the dynamics of their operations. The program offered intelligence gathering on a scale not available through public channels or consultants.

The national differences in motivations were interesting. The Japanese companies, with the exception of Honda, were not initially interested. Honda was the first Japanese company to recognize that North America would be its major market and that it had an interest in a study that could have a wide-ranging impact on the U.S. auto industry. When Japanese companies did become involved, they were most concerned about trade restrictions and tried to keep trade policy off the agenda. For their part, the Detroit auto companies wanted to control evidence that would indict their poor performance.

By the time the second phase began, the Japanese companies had clearly emerged as industry leaders. Why did they cooperate in a research project that would give away their success formula? Researchers had this to say:

> The Japanese companies were not worried about leakage of information and know-how. First, they doubted the ability of American companies to learn from them, and second, even if the American companies proved to be learners, the Japanese were confident that the Americans or the Europeans could never catch up with them because by then they would have moved far ahead.
>
> The Japanese also understand practice in a different way. They think it is matter of learning and cultural change, not just learning secrets and using formulas.
>
> The Japanese are confident that success is not about formulas. Publication of [The Machine That Changed the World] does not change anything. . . . They are confident that they have developed new competencies.

Thus, the Japanese were not afraid to reveal their operations. And participation in a research project involving the top engineering university in the United States would confer legitimacy and acceptability on the U.S. operations of Japanese companies.

A faculty member commented:

> If we take the industry characteristics and look at the national tendencies, it is easy to see why companies came together. . . . The Japanese have a history of knowing what others are doing, so this program gave them an opportunity to do so. Europeans, though, are a different matter and are the most secretive of the lot.

The European industry by tradition is suspicious of academia, fearing that academics always have a political axe to grind. The European companies were not sure the research would be objective and fair. However, some Europeans felt that the IMVP research would help academia understand the auto industry, that it would train the next generation of academics. These individuals worked to get both academia and industry involved in the project.

Now the program is so well established as a global forum for the industry that it is difficult for any company that considers itself a serious player in auto manufacturing to stay out of the program.

4.1.2 Evolution of Research Agenda

The research agenda evolves from the interaction of faculty interests, sponsor interests, and certain external conditions. A process of suggestions, recommendations, and revisions creates an agenda that does not pull too hard in any one direction and thus satisfies everyone.

1. Faculty interests

Academics participate in the research in order to understand and improve industrial practice. They want to get the whole industry to participate and then to translate the learning into industrially useful knowledge. In addition, when academics interact with industry people, they get to broaden their own knowledge base and to make their own work more practical and realistic.

2. Sponsor interests

In a cooperative research project, the agenda reflects issues of concern to the whole industry. The auto industry's main concern has been improving performance and quality. Thus the program began by analyzing internal operations, including plant operations, manufacturing, and product development. Once this analysis was done, the auto industry became concerned about best practice in functional areas other than manufacturing and at the ends of the value chain. Relevant best practices are not confined to the auto industry, and the sponsors are urging researchers to

study other industries as well.

Academics would like to continue benchmarking in order to measure and study change over time, but they feel it is harder in the third phase to convince companies to participate. Some sponsors seem to think that continued benchmarking is old news. Still, the success of the previous study may help researchers convince the sponsors that continued benchmarking will teach them something new.

3. External factors

Some of the automakers' concerns stem from actual or potential government regulations on pollution, emission control, energy use, and safety standards. International trade agreements also affect industry concerns. For example, the second phase addressed mostly internal issues, and although distribution was one of the main research areas, the results in this area were merely conceptual. At the time, distribution was not seen to be as critical as manufacturing. But in the third phase, the prospect of a unified Europe and a North American Free Trade Agreement are perceived as having profound implications for distribution practices. This is why research in distribution has now assumed so much importance.

4.1.3 Learning Curve and Life Cycle

One of the reasons that the research has been relatively slow on distribution may be that there is a gestation period -- a learning curve -- involved in understanding a research area. A senior faculty member at Sloan with years of industry research experience says that it takes about ten years to develop a body of knowledge.

Thus, the research process may be seen to consist of three stages: conceptualization, observation, and analysis. The researchers first develop an understanding of the industry and define the problems; second develop frameworks and test concepts; and finally draw inferences. For example, researchers in the first phase concluded that transformation of manufacturing practices would be one of the best possible scenarios for the industry. In the second phase they observed and analyzed changes in manufacturing. Now, after ten years, the program has developed a sufficient amount of knowledge to confirm the paradigm.

However, the distribution research was probably only fully conceptualized toward the end of the second phase, and therefore substantial findings have yet to come out of the program in this area. To illustrate, two years into the IMVP, the research director observed that "distribution seems to be a problem area because there is no evidence of any theory or overall vision to tie the work of the researchers together, much less to the

program generally." When he was interviewed for this report, he said:

> We only got our work together at the very end of the program. Thus, the chapter on distribution [in the book] was largely conceptual, comparing the best of the Japanese distribution systems with typical Western practice. However, the differences were so profound that our efforts to categorize them constituted a very useful contribution to management thinking.

The three stages might also be conceived as a research life cycle. The first phase produced overall analysis and an understanding of industry dynamics; the second phase led to a new paradigm or theory of production; the third phase will refine or extend the lean principle into supply and distribution and other functional areas. But for the external issues, the research in the third phase might have been incremental, more academic, and leading to a refinement of the lean paradigm with no new dramatic conclusions or paradigms. <Author: This concept isn't as clear as it could be. Do you mean that the distribution research life cycle might have started in the second phase, rather than the first? That different issues have different life cycles that overlap but are not congruent? I would clarify this.>

Still, the new focus on distribution and external issues has brought fresh ideas to the table, promising new insights over the next decade that will continue to engage the auto industry's interests.

4.1.4 Maintaining Intellectual Content

Academic researchers must meet industry's expectations, but they must also prevent the intellectual content of the research from being diluted. Programs that do not have academic applications for MIT could produce poor quality research that is too applied or situation-specific to yield significant educational benefits.

In the third phase, the program managers are making efforts to safeguard the research from becoming too applied. One of the researchers explained:

> <Author: This quote is a bit vague. Do you have a better one?>
> It is important to plan or conceive one's project in ways that involve some academic content and to use that [academic content] as a reference point to come back and develop the academic application and usefulness of research.

Other researchers mentioned the importance in avoiding a

consulting relationship for maintaining the research's intellectual content:

> The pull toward a consulting kind of relationship is also a pull toward a very customized pursuit of knowledge that is less likely to be generalizable, less likely to relate to the original academic goal. So it helps to be able to say that we are academic researchers and that we cannot pursue projects that are of interest to only one company or the other. We are not going to test or prove what the sponsors want to be proven to their internal customers.

4.2 Researcher Involvement

The recruitment of many of the IMVP researchers involved an element of serendipity. Krafcik, whose paper on New United Motor Manufacturing, Inc., (NUMMI) became the cornerstone for the assembly plant study, said:

> I was visiting the Sloan School to see if I should enroll here or at another business school for a degree in business administration. An hour before I was due to reach the airport, I saw this flyer asking for researchers with auto industry background. I called Womack. He saw me right away. We talked for twenty minutes and that clinched the decision in favor of Sloan.

The IMVP researchers included faculty members, graduate students, nonfaculty research associates, and professional consultants. The role and specific contribution of each category of researchers are discussed below.

4.2.1 Faculty

Most of the Sloan School's big research projects involving corporate clients are started and organized by a group of Sloan faculty. But with the IMVP, almost all senior faculty associated with the project were involved indirectly as thesis supervisors of graduate students. Several faculty members that had been involved in the first project moved on to other projects.

One reason for this difference may be that the Center for Technology Policy and Industrial Development (CTPID), which manages the auto program, sits between schools and does not have its own faculty. It has a limited claim on the time of any one faculty member.

Another reason may be the way research problems were defined. The key people in the program, both by inclination and perhaps past experience, did not want to frame the research on a disciplinary basis. They felt that disciplinary research, focusing on just economics or operations research, would not

adequately capture the dynamics of industry change. This approach may have affected faculty involvement.

The result was that MIT's academic community, with the exception of those faculty involved as supervisors of graduate students, did not take the auto programs very seriously. However, the program succeeded in attracting many faculty members from other universities. Roos explained this discrepancy: "The research in this program has enough academic content or value to be published, but the Institute does not recognize the research contribution of people involved with such programs."

The Institute's lack of recognition may have been a major deterrent to junior faculty involvement in particular. The functional and disciplinary focus in career evaluation further hinders junior faculty participation. However, with the success of the second phase, senior and junior faculty participation in the third phase has increased.

Despite its success, the IMVP has not fostered more interdisciplinary participation by other MIT departments. The only engineering faculty member involved with the program was one material science professor. Again, the failure can be attributed primarily to a career and tenure track system at MIT that rewards only disciplinary purists. Womack explained:

> Our efforts to get interdisciplinary academics at MIT involved were unsuccessful because they basically wanted to use the funds to fulfill their own research interests that did not fall within the overall interests of the research program.

4.2.2 Graduate Students

The program managers discovered that master's students who had industry work experience were as valuable to the program as doctoral students. Whereas doctoral students can bring academic rigorousness to the research, the practitioners have developed the skepticism and insight to ask fundamental questions.

Some of the key student researchers in the first phase were Martin Anderson, who had prior experience in policy analysis, and doctoral student Womack. In the second phase, key students included Krafcik, a Sloan master's student who had worked in a Japanese transplant; MacDuffie, a doctoral student at the Sloan School; and a few doctoral students at other schools.

4.2.3 Professional Consultants

The program's involvement with consultants has not been encouraging, and the administrators now avoid it. Consultants have their own interests, and their integrity is not assured. In

addition, they are not well versed in academic research methodology and find it difficult to adopt. It does not seem feasible for research programs of this type to involve consultants or consulting firms.

4.2.4 Full-Time Program Managers

Using full-time program managers from outside the university is problematic and unfeasible. The university cannot offer them the financial compensation and career growth that consulting firms can offer. At present, there is nothing in the system to attract such people.

In the long term, attracting capable people to manage such programs could become a real problem. It would be difficult to replace good researchers who had acquired an indepth understanding of the industry. The third phase has not yet found a suitable research associate, even though the vacancy has been advertised for eighteen months now.

4.3 Research Results

Most of the industry consortia at MIT are devoted to scientific and technological development. The auto program did not have a developmental agenda in the conventional sense, and it did not create any new products or technologies. Rather, it observed the industry's activities, assimilated highly technical information about those activities, and gave the information back to the industry in useful form. It actually produced knowledge.

4.3.1 Metamorphosis in Research Results <Author: I question the value of this subheading. I would eliminate it and renumber: 4.3.1 Interim and Final Results; 4.3.2 Synthesis versus Analysis; 4.3.3 Issues in Disclosure, etc.>

4.3.1.1 Interim and Final Results

During the IMVP, researchers disclosed results not only at the end but throughout the program via the policy forums. Sponsor feedback was a valuable corrective mechanism, and the third phase is adopting the same procedure. As a result of this intermediate feedback, the final results sometimes differed from the interim results (although such differences could also be attributed to the effect of combining all the projects into one broad analysis).

Not all research areas were fully addressed. Internal forces and priorities influence a project's emphasis. Some research findings are simply more important than others. In the IMVP, the interplay of these forces was evident in the research on human resources. During the interviews, some labor representatives who participated seemed unhappy that The Machine That Changed the

World understated the role of human resources in the Japanese production system. They believed that human resources were an extremely important variable in a comparative analysis of productivity.

Several researchers disagreed that human resource issues were not fully considered. Womack, one of the book's authors, said, "In the end, we did not have a separate chapter on human resources because this topic needed to be treated in several areas: manufacturing practice, product development, and managing the international enterprise."

MacDuffie, the key researcher for this area, said:

> The problem was that the organization of the book had been decided with a chapter for each major function of creating a vehicle. Thus [the sequence was] design, manufacturing, supply, and distribution. . . . Most of the human resources work was done as part of manufacturing research and tended to be reported with the manufacturing sessions in each conference. In the end it was simply the feeling of space -- that the manufacturing chapter could not be three times as long as others. Besides, there was a lot of data from the assembly plant study that needed to be reported so some of the measurement of human resource factors related to performance did not get included in the book. . . . In the description of lean production there was quite a bit of emphasis on the importance of human resources, and human contribution and teams were strong themes throughout the book.

Another researcher said that early in the second phase there was some discussion as to how much of the research effort should be devoted to human resources and union issues. But the United Auto Workers union was unable to give any money and, to some degree, this might have lowered the priority for these issues. Also, companies funding the research were pushing their own agendas and were not as concerned about human resources.

The quality of researchers also affects the depth and quality of research. The distribution area seems to have suffered for this reason. After two years of research, the lack of significant progress on distribution was causing program managers some concern. The research director explained:

> We had three primary distribution researchers, one each in Japan, the United Kingdom, and the United States. A combination of language problems, lack of ability to write, and lack of time due to other obligations meant that very little work was done.

Thus, although the issues are spelled out at the onset,

internal forces, resource constraints, prioritization, the nature of the topics, and other factors influence the issues that are addressed and emphasized.

4.3.1.2 Synthesis versus Analysis

Research projects like the auto program seem to lend themselves to two types of books. MIT's Management in the Nineties program took an analysis approach. In its book, each chapter was written by one researcher, and the program leader was credited as editor. Such an approach presents all the research results, but it can be repetitive and inconsistent. More important, it gives no overall picture. <Author: It was unclear to me if The Future of the Automobile followed the analysis approach. If it did, you may want to say so.>

In contrast, The Machine That Changed the World takes a synthesis approach, blending the findings into a holistic picture. At its best, such an approach leads to a paradigmatic understanding of the issues. But some academics feel that this approach dilutes research findings and deemphasizes or even eliminates some important issues. Moreover, such a book can be produced only if the program managers are intellectually interested in addressing the issues at a global level and if there is a high degree of cross-functional interaction among researchers, which leads to cross-fertilization of ideas.

4.3.2 Disclosure Issues

4.3.2.1 Confidentiality versus Openness

The sponsors' desires to protect information conflicted with the academic tradition of making research results public, particularly in the second phase. Many companies did not want the results of the assembly plant surveys and the quality and productivity comparisons to be published.

The program managers negotiated a compromise that the company identities would be disguised and the research papers would not be published until they had been adequately reviewed by the sponsors. But under no circumstance would the general results be withheld. Internal memos document the researchers' efforts to straddle these concerns:

> We have tried to summarize findings in an effective way that will not cause any embarrassment to any individual European producers. . . . We have left off the "best" and the "worst" data points, leaving any company free to say that the European average may not be so good but that their performance is "world class."
>
> We have decided to go ahead with this article since it has

been six months since the Como forum papers were sent to sponsors, and to hold back any longer would mean we would simply never publicize our findings. . . . [Companies] may protest but we should be prepared to explain once more that universities are in the business of publishing their findings. <Author: The brackets should indicate whether this was an individual, company, or companies that "may protest."">

Prior to the book's publication, the authors gave a draft to program sponsors and asked for factual corrections, but the authors retained complete control of its contents. Despite these precautions, a researcher's comments were misrepresented in the press, and some sponsors felt that their image was damaged. The impact of this incident can be felt in the third phase, where the sponsors have categorically asked the researchers not to do any comparisons by country or region.

4.3.2.2 Industry Impatience versus Academic Deliberation

<Author: This section seemed a bit disorganized and occasionally too sketchy. I've rearranged and revised some of it. Please review.>

Academics, by training and disposition, are averse to publishing research results until they have been thoroughly verified. But industry sponsors are often impatient. They need the information to respond to competitive pressures as rapidly as possible. The industry liaisons themselves are under pressure to produce results, and their careers may be affected by the timeliness and nature of the results. Also, it is common for sponsors to have an engineering or physical science model of research; they don't understand how social science research is different. They think organizational change can be studied just as technical solutions can be invented. In reality, understanding organizational phenomena takes much longer, and implementing organizational change is more difficult.

The academics have their own issues. Their careers, too, are heavily influenced by the project. They already have the problem that the work is not considered "pure" because it is applied and interdisciplinary. Then they are under pressure to rush results to the press before the research is evaluated by academic peers, which can further endanger the research's academic acceptability.

The IMVP administrators felt these pressures. They could not concentrate on publishing research papers in academic journals because this would have been at the cost of developing implications for industry. It is not surprising that The Machine That Changed the World is widely acclaimed by industry executives and practitioners but not by academic colleagues, who think the empirical basis of the research has yet to be tested. <Author: In

the executive summary, you state that the books furnished "empirical proof." Is this a contradiction?>

To address these problems, industry must learn to take a long-term perspective, and academics need to invest more effort in educating the sponsors that there is a gestation period involved in developing a body of knowledge.

4.3.3 Dissemination

The auto program diffused the research results through some conventional and unconventional channels. Atypically, the IMVP program managers considered their primary audience to be industry practitioners and other decision makers outside academia. Reaching an academic audience was important only for those researchers who wanted academic careers, and therefore the task of diffusing the information in academic circles was left to them to do on their own. As most of the researchers were not looking for academic recognition, this diffusion was much less than is usual in university research programs.

Once a year results were presented at a policy forum in a different participating country. The research findings were sent in advance so that all forum participants were familiar with them and so that the sponsor representatives could discuss them internally before attending. This made the interaction more meaningful and ensured substantive, regular feedback on the research.

In addition to the forums, every fall the program cohosted a seminar with MEMA for suppliers. The researchers gave presentations to corporate audiences by invitation, participated in conferences and symposia organized by MIT's Industrial Liaison Program, and presented papers at other conferences and symposia. About twenty research papers out of more than a hundred were published. Some articles appeared in business journals and industry journals, and the findings were available to the general public by request.

However, none of these methods was as successful at diffusing the information to a broad, diverse audience as the books. The Future of the Automobile and The Machine That Changed the World, which were published at the end of the first and second phases, respectively, were able to present the information holistically to a large audience. They succeeded in part because the authors addressed the information to general readers and avoided sounding too theoretical and pedagogical.
After the experience of publishing the first book, the program managers treated the second book as a commercial project from the start. They used all means typically employed by publishers to launch commercially successful books, such as engaging a professional writer, creating advance publicity, and doing a

commercial launch. This is quite uncharacteristic of most books written by academics.

4.3.4 Books as the Most Visible Products

4.3.4.1 The Future of the Automobile

The Future of the Automobile was published in the centenary year of the automobile industry. It confronted the prevailing wisdom that automobile manufacturing was a mature industry to be phased out by rising oil prices and environmental constraints. On the contrary, it asserted that the industry's technological base was strong and that it would continue to be the world's largest manufacturing activity.

Looking ahead twenty years, the book concluded that the automobile was secure as the prime means of personal transportation and that the industry would remain the biggest in the world. At the end of the first study, there was a widespread belief that the industry had returned to profitability and stability.

Business Week named the book one of the ten best business books of 1984. Many reviewers called it an essential reference for anyone concerned with the auto industry. Others said that the study set a new standard for global industry studies.

Although the book was a collective effort, it did not seek to present a consensus view. Rather it attempted to interpret and analyze the auto industry's problems and predict how the industry would evolve. However, it stayed away from specific recommendations and simply presented underlying trends.

This book established a bridge between academia and industry and convinced government and industry leaders that the Institute could play a vital role in the industry's evolution by bringing together key people to explore important policy options and their implications. The industry also realized that the university's neutral setting was an excellent place for addressing the political and social implications of industrial changes.

4.3.4.2 The Machine That Changed the World

The first book predicted industry transformations, and The Machine That Changed the World tried to explain how these transformations were taking place. Although everyone was aware of the quality of Japanese cars, the process that developed and produced these cars was not well known. The companies did not yet know that the advances in manufacturing methods made in Japan during the 1950s were as fundamental to the organization of work as the discoveries made by Henry Ford. Also, studies about the Japanese industrial system until then had tended to focus on

specific issues such as wage differentials, currency exchange rates, or government protectionist policies and subsidies. Efforts by U.S. companies to selectively adopt aspects of lean manufacturing such as just-in-tine inventory or quality circles had often proved disappointing.

The IMVP research provided the first documentary evidence that the Ohno system was transportable. The system did not, as Detroit had long believed, depend on Japanese workers and suppliers. The book clarified that the secret of Japan's lead was not advanced technology or low wages or some mystical Asian work ethic but its management system -- the way it dealt with employees, suppliers, dealers, and customers. The study established that the superiority of the Japanese management system boiled down to a few elements, including teamwork, efficient use of resources, and a tireless commitment to improving quality.

The book clearly stated that a fundamental restructuring of the manufacturing system was need. It identified the best practice techniques in all phases of automotive production. It also highlighted an overall framework for the entire production process. The research showed that the Japanese spent less time designing cars, used less effort to manufacture them, produced fewer faults, and, by eliminating wasted effort, could afford to make a greater variety of vehicles than the average U.S. or European car factory. These conclusions were backed by reliable statistical measures. Thus the book offered convincing evidence that the traditional mass production system used by U.S. and European automakers was inferior to the production systems at leading Japanese firms.

The book also presented the new production system so that it could be applied generally to other industries. In the Anglo Japanese Journal, Sir Charles Villiers said, "You can substitute the word 'car' in this definition of lean production with any other product or process or service, and it would still make sense and be appropriate."

The book was a dispassionate, unbiased study that gave credit where it was due and criticism where it was warranted. It did not spare any U.S., European, or Japanese manufacturer. It also did not solely praise the Japanese production system, specifically criticizing its human resource management practices. Yet U.S. and European automakers, particularly GM, were initially unhappy with the book. The program director commented, " A lot of people were critical of our message when we first came out with it, but when things died down, most of them agreed with the findings." <Author: It might be useful to mention what GM and others specifically didn't like about it.>

In a review in Automotive News, John F. Smith, Jr., vice

president of GM, is quoted as having said that the book clearly identified the direction in which companies must go to compete globally with the Japanese. In another interview, a BMW spokesperson admitted that the company's only major disagreement with the study was that the German automakers spent up to 10 percent and not 30 percent of all assembly hours in rework and repair. But he said that the basic premise of the study was definitely correct. Another European company that had threatened to sue MIT retracted its stand. It is rumored that in a meeting with MIT president Charles Vest, the company chief executive thanked him for the contribution of the IMVP study and for the awareness the book has created in the auto industry. <Author: I would delete this sentence, considering that it's based only on a rumor.>

The Financial Times, a leading British business daily, named The Machine That Changed the World the best business book of 1990. It was also listed as the fifth best business book of the year in the United States, where Michael Porter's The Competitive Advantage of Nations reigned first. <Author: I would state who listed it fifth -- or was it the fifth best-selling book?> The book was reviewed in many trade journals, financial newspapers, and other dailies across the country and overseas. Fortune called it an authoritative, extremely timely, highly revealing, and ground-breaking study. Many other reviewers said that the book might be the best written about the auto industry since Peter Drucker and, before him, Alfred Sloan.

The book reached audiences well beyond the auto industry. It was read by senior government officials and in public policy circles and universities. It was also translated into seven languages. In Germany it became the best-selling business book. Overall, it has sold close to a hundred thousand copies, ten times that of The Future of the Automobile.

It is worthwhile to note that both books dispelled conventional wisdom and predicted scenarios that have been borne out since. It is also interesting that many academics, at least initially, held the books in low regard. The only negative review of The Machine That Changed the World that I came across was an extremely negative one written by academics at the University of Michigan's Transportation Research Institute.

Within MIT, the book had its critics, too. The program director recalled that after the book was published, he was attending a meeting when a senior faculty pulled him aside and said, "This is just the kind of study we should not be putting out at MIT. We should be either doing deep research or putting out instructional materials to help with the teaching of our engineering and business courses." However, as the book became a celebrated success, this particular academic changed his appraisal.

4.3.4.3 Attendant Issues

It has recently become a tradition to conclude multisponsor research programs with a book. Examples at MIT include the report on the Commission for Industrial Productivity and the book of the Management in the Nineties program. <Author: Can you give the exact book titles?> Should every research program produce a book? Certainly the books in the auto program were successful. One consideration may be whether academics are able and willing to avoid academic jargon and write clearly enough for laypersons.

Another issue in publishing a book is the credit given to researchers. Although the researchers provide the basic inputs, they do not write the book and are not credited as authors. Some researchers in the auto program seem unhappy with this. In The Machine That Changed the World, only the program managers are listed as authors. Similarly, some researchers feel they should receive royalty income.

4.3.5 Academic Recognition

The second phase has yet to publish many research papers in scholarly journals. Of the 116 research papers and monographs produced, only 20 have been published in academic journals so far. Most of them are available through the CTPID.

As I've said, the IMVP placed more emphasis on communicating with industry than on securing academic recognition through publications in scholarly journals. The researchers themselves may not have been motivated to publish because most of them were not looking for academic careers.

Another reason for the lack of publications may have been that the typical publication sequence was reversed. Usually researchers publish papers and then combine a few of them into a book. The IMVP's time frame didn't allow for that sequence. Now the book has become a shorthand way of referring to the actual research papers. By virtue of its popularity, the book has overshadowed the indepth empirical research. It is too early to tell how many papers will be published and how they will be received by academics.

In contrast, the papers written as doctoral dissertations and theses have received considerable academic acclaim. For instance, Krafcik's thesis received Sloan's award for the best master's thesis of the year, and MacDuffie received the Zantos award for the best doctoral student thesis in the Sloan School. Both theses are cited frequently in related subject research papers, just as the Abernathy-Utterback model is cited in any study of innovation.

One of the researchers who has chosen an academic career

said:

> I have received a favorable response to my research in academic circles. Large-scale publishing of research papers is yet to take place, so it's to be seen whether people are starting with some bias against the work because its most visible product, the book, is considered by some academics to be slick, mass market oriented, and superficial. . . . The book as a single product of the program certainly got more attention for its authors than for any of its other researchers.

It is hard to judge whether the program should have rushed to get papers published before the book and whether that would have changed the course of things. The papers were written primarily to communicate to the industry audience rather than an academic audience. Another researcher commented:

> Still, [the research papers] were done in a rigorous way so that they would show care and attention and analytical statistical justification . . . even if they did not adopt the full form of an academic paper. The papers that were based on empirical data will be able to make the transition [to scholarly publication] more easily, but probably the papers based on case studies might not get wide reading in academic circles, probably due to the more positivist bias for quantitative research than for qualitative research in most business schools.

However, "Learning about NUMMI," a qualitative paper that was also the first paper written in the program, did get a lot of exposure.

Publication in academic journals seems to be a function of time and not merit. Papers are often accepted for publication almost a year in advance. The program would not wait for the research results to be published because the book could lose its timeliness. However, placing emphasis on academic publication at the onset of the program may help ensure early academic recognition.

4.3.6 Byproducts

The research process can sometimes yield byproducts, such as analysis tools and computer programs. During the IMVP, the researchers developed an analysis tool for monitoring plant performance. Many sponsors have expressed interest in using the tool, but the program has refrained from giving it to them. MacDuffie explained:

> We sent a customized report to each plant that participated in the assembly plant study after analyzing its performance

based on survey response. The reason I do not want to prepare a blank spreadsheet for any plant is that I think these need to be customized, . . . and it would be difficult to let everyone do this. . . . We could train the industry people to conduct such analysis, and then they could be given the software to do it.

The program managers have a dilemma: on the one hand the tool could be useful to industry; on the other hand, they would like to ensure its correct use. In the absence of any formal mechanisms for doing this, the tool is not being transferred to the industry.

There are other issues. If sponsors are interested in using a tool developed during the course of research, should it be free or licensed? Should licensing be done through MIT's technology licensing office? Who owns the rights to the tool -- individual researchers or the program? Who will do the technology transfer and training?

Two software tools are also being used in the research program that sponsors are likely to ask for. Obviously, some transfer mechanism and guidelines need to be outlined.

4.3.7 Industrial Application

Traditionally, the U.S. engineering and scientific community has a low regard for the managerial side of technology. The IMVP research proved that technology alone is not the key to competitiveness, as this community believed. The hard evidence unearthed by the researchers about productivity and quality enabled firm managers to justify and execute corrective action to improve performance.

The research has changed managerial attitudes in other countries as well. For example, the social contract in Germany and Sweden has not allowed workers to be laid off. The research evidence made the idea of cutbacks and layoffs politically and socially palatable. Some can argue that this has harmed workers' interests, but at a broader level, society benefits from more efficient production.

There is some evidence that the research tools developed for the program are being used in industry. Many individual plants have begun to track the variables that were measured in the assembly plant study. In Australia, the Automotive Industry Association (set up by the government to monitor the industry) asked the researchers to write a guide to the assembly plant study so that plants could track the variables themselves. The Association then asked all the plants in Australia to fill out the survey. The Association analyzed the data and gave feedback to the plants the way IMVP researchers had done during the

program. The researchers also prepared a guide to track assembly plant performance for Australia and subsequently produced a version that was available to anyone.

In addition, two companies asked the researchers to prepare a tracking report for new plants, and GM Europe developed a spreadsheet based on the assembly plant survey questionnaire.

4.3.8 Active Involvement in Dissemination

Efforts to translate research learning into a body of knowledge that can be used in the curriculum happen mostly at the individual faculty level and less at the departmental and institutional level. A faculty member said: "What is needed is more distillation and dissemination of such learning as an active, objective -- not passive, inadvertent -- circumstantial outcome." However, there may be little incentive to do this because of the institution's lack of recognition of the research's educational contribution. <Author: Is this what you meant by "because of the imbalance, between recognition of research contribution and educational contribution"?>

In industry, too, disseminating research results needs to be more effective. Industry sponsors are asking for new tools and training to implement organizational changes. They are not completely satisfied with the present mechanisms. Policy forums are limited to a couple of representatives from any sponsoring organization. Research papers, although easily distributable, are not tremendously effective. The book creates wider awareness but is too generalized to help in actual implementation. Other efforts -- faculty members giving guest lectures individually and through the Industrial Liaison Program; consultants translating MIT research into industrial practice -- are too fragmented to have much impact.

However, faculty members feel that academics should not get too involved in actual implementation. One said:

> A university person who studies organizational phenomena is detached from the culture of the system; he misses the social culture of the context. This distance from organizations helps university researchers spot general trends that help organizations to redirect their energies. However, since determinants of organizational change are strongly culturally dependent, the distance of academics makes them ineffective as implementors of organizational change.

Most of the interviewed faculty members do feel that there should be a more active involvement in disseminating research results to the industry. In the third phase, some projects have been initiated that involve academics working with interested

companies to develop, implement, and monitor experiments in best practice techniques based on the research findings.

Some faculty members believe that dissemination efforts must be institutionalized to be more effective. One faculty member suggested that this could be done by creating a new structure affiliated with MIT along the lines of Harvard's publishing division. The new structure could develop instructional aids -- using multimedia technologies, training manuals, lecture notes, and videos -- or conduct programs for organization employees at different levels. The office could provide companies with material for internal training programs, given the university's constraints on facilities and faculty time. One-day seminars for company participants on specific issues like TQM and technology transfer could be organized. Company participants could also be invited to share their own industrial use or implementation. <Author: Do you mean participants could offer their companies as study sites? Or do you mean they would share their experiences?>

Other faculty members are reluctant to support such activities, believing they would take time away from research and are not part of MIT's mission.

V Negotiation Aspects

5.1 Negotiation Process

Although the antipathy between industry and university has faded in the 1980s, the negotiation process continues to be complex, difficult, and time consuming. Industry-sponsored research has to meet two objectives simultaneously: serving industry and advancing the career and professional goals of faculty. This requires a process of matching industry and faculty research interests.

For the auto program, the focus of negotiations changed over the course of the project:

Research program stage	Focus of negotiation
Early stages	Participation, funding, research agenda
Interim (research agenda is finalized, and the researchers are collecting data)	Access to information, executive time
Final stages	Presentation and disclosure of results

5.2 Components of Negotiation

There are five components involved in negotiating the research program: participation, funding, process facilitators, agenda, and results.

5.2.1 Participation

In science and technology research, sponsors provide funds, and information flows in one direction, from university to industry. In IMVP-type programs, sponsors provide funds and share knowledge. In order for researchers to do a realistic study, this knowledge must include information that is usually not available in the public domain.

The first phase of the auto program was financed mostly with grants from the U.S. government and foundations. The participation of individual company sponsors was practically nonexistent in terms of both funding and information exchange. Most of the research was based on information already available in the public domain. However, the success of the first phase captured industry interest and established MIT's credibility.

There were two reasons for this new interest. The first

phase predicted a promising outlook for the industry at a time when a sense of doom prevailed. The book's optimistic forecast caught the attention of industry executives who had traditionally disregarded outside opinions. In addition, the results of the first phase convinced them that MIT was capable of conducting research that might help them understand the dynamics of changes that were taking place. This credibility made the negotiations with companies in the second phase somewhat easier.

By the end of the second phase, attracting company participation was not an issue. The program enjoyed so much visibility that it was difficult for any major player in the auto industry to stay away. This has tilted the bargaining position in favor of the university. An interesting incident in the third phase bears this out. As the program was negotiating with companies over the terms of participation, one of the larger companies stipulated preconditions that were not in the program's interests. When the company threatened to leave the program, the program administrators were willing to let it go. In the end, the company stayed.

Still, a number of participation issues continue. Program managers have to negotiate funding levels and access to sponsor employees and facilities. Although researchers have built networks with industry executives that should facilitate the process, more convincing is required to gain access to information because the companies are more afraid of information leaking and of company identities not being adequately concealed.

At the May 1992 policy forum, confidentiality was the executives' major concern. The general consensus seemed to be that although everyone recognizes the usefulness of comparative analysis, no one company wants to be identified even if it is recognized as the best performer. As a result, some researchers have signed agreements with individual companies that they will protect their data source.

5.2.2 Facilitators

A number of people outside MIT helped bring the auto companies and other stakeholders from Europe, Japan, and North America into the program, particularly in the second phase. One of them was Jay Chai, a Korean who was then the executive vice president of CItoh & Company (America), Inc. <Author: Should this be Citoh?> Chai had the unique position of being widely respected by both American and Japanese auto industry executives. He had his own reasons for promoting U.S.-Japan understanding, and he saw the IMVP program as a good opportunity for bringing people from both sides of the industry together. <Author: You should indicate what his reasons were. Perhaps his company's products are related.> In Europe, Dan Werbin and Don Kress, a semiretired Booz-Allen consultant, opened the doors for MIT at Volvo and

Renault, respectively. <Author: Explain who Dan Werbin is.> Colleagues in other academic institutions like Daniel Jones in Europe and Shimada in Japan also directly or indirectly attracted some sponsors. <Author: No second name for Shimada?>

5.2.3 Funding

Both the source and amount of funding have a direct influence on the research agenda. As stated previously, it is easier for academics to retain control over the agenda when the sources of funding are nonpartisan agencies like governments and foundations. However, in international programs governments can try to tilt the agenda in favor of the local industry. A portfolio of sponsors can limit sponsor influence, but it also intensifies the fundraising effort and multiplies the number of different demands made on the researchers.

The IMVP's funding was structured to give the university a strong bargaining position by using a distributed negotiation strategy in reverse. The amount of funding from any one company sponsor was limited to less than 5 percent of the total program budget, which meant that no one sponsor could control the agenda. The administrators also raised equal amounts from the three geographic regions so that no regional alignment of industry competitors could exert pressure and skew the results.

5.2.4 Scope of Research

While recognizing that industry is the customer, the researchers cannot neglect the internal customer that is the university. The program administrators have to ensure that the subject of research is worthy of intellectual enquiry and that the program fits with the university's educational and research missions.

Further, the university has to play a societal role and ensure that other stakeholders, who are otherwise left out of the decision-making process, are either directly involved or represented in the research questions. The program has tried to link the auto component suppliers with the research about auto assemblers. A number of suppliers -- AKZO, Du Pont, Montedison, Robert Bosch, and TRW -- were sponsors of the second program. A number of Japanese suppliers were represented through the Japanese Auto Parts Industries Association, the Mexican Auto Parts Industries Association, and MEMA. The heads of these associations were also delegates to the policy forums. In addition, under the auspices of MEMA, the program held an annual supplier seminar for about thirty-five U.S. firms during each of the program's four years.

5.2.5 Research Results

Once the research results are ready to be published, negotiation activity becomes hectic. The academics want to put everything in the public domain, and the industry sponsors are ambivalent. They sponsors want publication of results that portray them in a positive light but want to withhold negative results from the public domain and other participants. The results of the IMVP program were sent to the sponsors before publication for factual corrections only. Some companies pressured the administrators for changes or deletions, but the administrators did not make them. This has served to strengthen the university's bargaining position as the third phase moves ahead.

There is also an internal struggle over the results' ideological slant. The program has learned to steer clear of such problems. In the first book, some MIT economists who believed strongly in free trade objected to the chapter on managed trade. Their criticism held up publication by the MIT Press for some time. Perhaps this is why the MIT Press did not publish the second book.

The program administrators also negotiate internally for facilities, faculty time, and other institutional resources. MIT allows its faculty considerable leeway to pursue a variety of research interests, provided the programs can generate their own funding and do not violate basic ethical guidelines. MIT considers its faculty members "research entrepreneurs," whose research ideas are accepted without question if they can find sponsors. Thus in a flexible institution like MIT the research agenda is defined at the faculty level. Moreover, administrative influence is limited as long as the program can stand on its own financially.

The negotiation process with external agents, particularly sponsors, is undeniably the most complicated part of the process. Industry must be able to influence research without controlling it. Sponsors who perceive themselves as wielding influence are more motivated to participate and apply the research to practice. But academics also have to uphold their academic freedom and integrity. Therefore the ideal power balance is achieved when industry sponsors bear considerable influence on the research process, but the faculty maintains control. Company sponsors should act as navigators, but the steering wheel should remain in the hands of the faculty.

6.1 Why MIT?

The university provides a neutral place where industrial organizations can come together to learn from each other. It is unlikely that a research program of this magnitude could have occurred in any other context. MIT is considered the best technology institution in the world, and it has a tradition of working on problems that are close to the automotive industry. MIT has done automotive research for twenty to thirty years and fuel research for fifty years. <Author: I would say either twenty or thirty years, not both.> Moreover, in order to fulfill its societal function, the Institute has undertaken projects that address industrial issues of national and international importance. MIT was the most likely place for a research initiative combining technology with organizational theory. No other business school has the same level of experience in addressing technology issues. The IMVP program director explained:

> MIT, . . . having done an international project on the auto industry in the late 1970s and early 1980s, had developed international contacts and expertise and had a base of knowledge on which we could go further sooner than any other institution.

Thus MIT's success has been due to its unique position as a highly regarded technology institution that could obtain cooperation from all the major players, including industrial organizations, governments, suppliers, distributors, and users.

6.2 Did MIT Act as an Industrial Consultant?

Critics of the IMVP argue that MIT acted as an industrial consultant. A key researcher who has chosen an academic career responded to this criticism by saying that indeed this type of research does not qualify as "pure" academic research, but it also does not proceed like a consultancy project. It falls in a grey area. The researchers want the results to be useful to the industry, and the industry's problems certainly influence the research questions and agenda. But the researchers also maintain their academic integrity by ensuring that the research is accurate and reliable, and they investigate the issues at a much more fundamental level that consultants do. The surveys and other forms of data collection are necessary to test hypotheses, but the IMVP study did not make any projections, as a consultant is usually expected to do.

Does the IMVP project, like a consultant project, attempt not only to describe problems but also to solve them? Another

researcher explained that the project tried to stay away from offering implementation advice but that The Machine That Changed the World clearly advocated adoption of a lean production system in place of conventional mass production techniques. There was no attempt to be neutral on that aspect. Still, the book did not prescribe any implementation strategies to achieve lean manufacturing.

However, now industry managers are demanding that MIT help them implement the changes. One of the researchers commented:

> To some degree it's okay, but I do worry that if we go too far in that direction then we get into all these problems of consulting relationships. It's all right to do research on implementation that can help identify patterns that successful implementors should use, but implementation per se is a very situation-specific exercise.

Another faculty member associated with the program said:

> It's true that although industry understands the research results, it is not necessarily successful in implementation. Organizational change is very difficult to implement. We have not attempted to help industry implement changes, but we are moving toward a better understanding of organization change. Companies will have to evolve their own application process; academic research can only evolve models of change.

Academics can provide tools for implementing changes and new practices. But actual implementation is not related to academic research, and IMVP has clearly not crossed that line.

Thus the criticism that the IMVP put MIT into the position of acting as a consultant does not seem valid. As the program director explained in a newsletter, "Our role is not to set policy or make recommendations. We intend to help people understand the issues and so assist those with policy-making responsibilities."

The program has attempted to inform policy makers in governments, companies, and labor unions of the forces at work so that they may devise more creative, informed, and productive strategies to deal with the industry's dynamics in a global economic and political system. One senior faculty member said:

> University academics are not problem solvers. Therefore they cannot be considered industrial consultants in any way. The unique competence of university researchers lies in their ability to do more fundamental, theoretical, and long-term research and in those areas where a company cannot do it internally.

6.3 Relevance to MIT's Missions

MIT has two basic missions: to educate and to pursue knowledge through research. Any activity carried out within the institution must contribute to these missions. Therefore, the relevance of the IMVP to the Institute must be measured in terms of its contribution to these missions.

6.3.1 Education

While science and engineering theories are fairly robust, management-oriented theory and decision-making policy are more limited because social phenomena are difficult to define. Nonetheless, the experiential and experimental learning that takes place in IMVP-type research programs is valuable educationally because it accumulates knowledge that can be used to develop courses and determine research opportunities in more purely technological areas.

Research programs like these provide the kind of paradigmatic learning that cannot result from the usual academic research, in which research questions are narrow, focused, and discipline- or situation-specific. Efforts to get close to practice also provide an opportunity to fundamentally rethink concepts and one's problem-solving approach. For example, the analysis of assembly plant data produced a new theory of production. Thus learning through such programs helps fill gaps in social science or management theory and eventually has an impact on science and technology education.

The research's educational value is also evident in the material it has provided for course development and case studies and the opportunities it has provided for graduate students. Tom Kochan, a Sloan professor, explained:

> As a result of the experiential type of learning opportunities that research programs like IMVP provide, the students at MIT are much more conversant with real-world problems and companies find our students much more on their feet and up to speed.

<Author: I question the value added by the two quotes from graduate students. I've deleted them.>

A doctoral student, whose thesis was based on IMVP research and who has chosen an academic career, said:

> There is a much more direct relationship between some of this research and curriculum teaching than with some other research. This research is so close to the industry and still tries to draw out universal principles. . . . Some of

> the auto research showed organizational principles and conceptual shifts in management functions such as quality and inventory and performance improvement that had broad relevance. This makes it easier to bring it in the classroom with impact.

One cannot generalize that all such research programs would have this kind of academic impact. Powerful new practices were emerging in the auto industry that challenged conventional wisdom. The auto program had the opportunity to detect a paradigm shift and develop it. A management professor associated with the research explained:

> Those of us who are staying in academic careers have the greatest potential to make an academic impact . . . by using the data we have and will be gathering to point out the limitations of past theories.

Such research also provides universities with the opportunity to internationalize their faculty and research. As businesses globalize, they need managers who understand international dynamics and who can function in different cultural settings. Research that involves multicountry, multicultural sponsors helps business schools prepare such managers. It trains faculty in international issues and allows them to come in contact with academics in other countries. This exposure in turn helps them develop knowledge in a global context. The learning that results can then be distilled into the curriculum. For example, Michael Cusumano uses material from IMVP research in his course on Japanese technology management. Similarly, the research is expected to yield material for courses on environment and public policy offered by the Technology and Public Policy Program. The most significant educational output of the program is the case study that is used by the Sloan School in senior executive management programs. If more senior faculty were associated with the research, the carryover of research insights into the curriculum would be on a much larger scale.

This kind of systemic study of the interaction between technology and human beings is also having an impact on engineering. Joel Moses, dean of MIT's engineering school, cited lean production as one of the basic components of postmodern engineering. However, the process of changing curriculum and educational policy takes a long time. It will be quite awhile before the impact of the research can be seen in the structuring of the engineering curriculum.

6.3.2 Research

The IMVP has established a new research methodology for studying competitive issues and best practice in an industry. Business school researchers have long been concerned about the

impact of management practices on performance, but the IMVP research succeeded in developing a better understanding of that impact. Typically, research has focused on management practices and evaluated them by measuring performance. But direct measurement of performance is difficult, and most researchers have accepted some limited or indirect measure. An IMVP researcher explained:

> The IMVP research methodology was an unconventional path, but there was a reason for us to feel that a lot of old paradigms were no longer relevant. . . . And even though some might cling to them, more influential people [industry executives] will be open to our new ideas.

Prior to this research, academics had never done a study that used quantifiable performance measures. But although there was no academic precedent, benchmarking was often used in the industry. The research director said, "[The approach] needed unconventional researchers and researchers that came from the industry with enough industry knowledge to . . . put together the pieces in a slightly different way."

The program also allowed researchers to work on site and gave them much more access than is usually available to an individual researcher. A doctoral student said that he was drawn to the program's "hands-on bias. . . . The research was so close to the phenomenon."

In addition to contributing to methodology, this type of research points out areas of science and technology research that need to be addressed. For example, the IMVP research suggests that auto companies need research in applying technologies involving energy use, electronics, materials, and telecommunications. A study of environmental issues can lead to mainstream technology research in new fuels and materials. A study of urban transportation issues could lead to high-tech projects like the Intelligent Vehicle Highway System and smart cars.

Although the long-term impact remains to be seen, ten years of auto research have accumulated enough evidence to show that the research has a direct relevance to MIT's educational and research goals. As MIT aims for all-round excellence that embraces social science disciplines as well as technology and science, the impact of social science studies of technological systems can be far reaching. Thus, while such research programs can add to management theory, they are also valuable in understanding technology and predicting technology trends.

But how methodically and effectively does MIT as an institution capture the learning from these research programs?

VII Institutionalization

7.1 Institutional Precedents

<Author: I wonder about the value added by 7.1, given that it isn't necessary for understanding the rest of the section. It seems more appropriate for 2.1.>

Three institutional events set the stage for the IMVP. "New Perspectives on Urban Transportation Systems" was an MIT program from 1975 to 1979 that was funded by the U.S. Department of Transportation. It laid the intellectual foundation for the auto programs. At the culmination of the study, the associated academics, researchers, and students had developed the knowledge of the auto industry that would prove useful in the auto program's first phase. <Author: Is this the same as the Cooperative Automotive Research Program? If so, use the same name here and in 2.1.>

The "Made in America" research involved a set of industry studies prepared by renowned academicians at MIT. This project set a precedent in that it was interdisciplinary and involved a significant number of senior faculty who were authorities in their own disciplines. The project proved that nondisciplinary research could be viable and well recognized.

Finally, the first phase of the auto program provided a learning experience for the program administrators and researchers who went on to work in the second phase.

7.2 Institutionalization

As the auto program enters its eleventh year, many issues that have implications for MIT as an institution need to be examined.

7.2.1 Governance

Whether the present governance mechanism for the program within the university is feasible in the long term is difficult to say, but there are some needs it is not meeting. <Author: I'm not sure which needs you mean. Can you spell them out?> Many questions have yet to be discussed: can the present system be changed to accommodate these needs or should a new system be developed? Should a separate organization, affiliated with MIT, be created to manage all such programs? During World War II, MIT created laboratories associated with the federal government, such as the Lincoln Laboratory and the Instrumentation Laboratory. These labs allowed the Institute to dissociate itself from classified research, which was likely to be viewed as incompatible with the university's purpose, while still maintaining some actual involvement with it. Perhaps industry-sponsored research programs need a similar structure.

7.2.2 Long-Term Research Direction

Federal funding for university research is steadily decreasing, and MIT is looking to industry for greater financial backing for research. Competition for such financing among federal labs, nonprofit research institutions, and universities will only intensify. Does this mean that multidisciplinary, vertically integrated, interactive research programs would or should become a greater part of MIT's overall research component? Obviously, MIT's reputation for scientific excellence and service to industry places it well to take advantage of the increasing demand for such research.

7.2.3 Reward System

The present reward system and the focus on disciplines dissuades many faculty, particularly junior faculty, from getting involved in research programs whose disciplinary links are weak. If the Institute wants to encourage more research programs like the IMVP, it will need to change its system of performance evaluations and promotions. Harvard Business School's system, which separates education and research activities, does not seem feasible for MIT, partly because of MIT's smaller size. In addition, such segregation may weaken the links between research and teaching. <Author: I'm assuming when you said that size was an issue that you meant MIT is smaller.>

7.2.4 Continuing Education

I have previously said that the Institute needs to more actively disseminate research results to industry. One way it might do this would be to set up a separate structure that handles continuing and lifelong education. Continuing education is important for professionals who rely on their technological skills, particularly for engineers. With technology changing so fast, skill obsolescence is a real problem.

There are many advocates of continuing education in the Institute. In 1982, in the centenary year of the electrical engineering department, a faculty committee set up to assess the need for MIT's participation in continuing education strongly recommended such an involvement. <Author: Did they recommend the separate structure? If they did, say so.>

Last but not the least, such a setup could be a big source of revenue for MIT. A company could fund research efforts in exchange for continuing education for its employees later.

7.2.5 Societal Role

By participating in such research, the university can act as a broker, helping government, industry, and the public resolve

community issues. The university provides a platform for different constituencies of interest to come together in a nonthreatening atmosphere. Similarly, the university provides a stable organizational framework for activities that require learning by experience. As a facilitator, the university can identify stakeholders, foster communication, and help the players forge a consensual decision-making approach. It can also make sure that problem solving addresses issues at a global level, transcending local, regional, and national boundaries.

Fundamentally, institutional issues boil down to a few questions: Should the university be a silent bystander to social and industrial changes, or should it wait for a cue from the players, or should it be proactive? Should market forces operate on their own, or should the university act as a moderator or coordinator, protecting the interests of weak or excluded groups? Can the university play a role in developing standards for unstable or still evolving public use technologies? All of these questions must be debated at the highest levels by all those who are responsible for shaping the Institute's future.

VIII Recommendations

My principal intention in undertaking this study was to help program administrators and faculty members who are conducting research programs associated with industry, particularly those doing research that involves many companies in the same industry. The study suggests some conclusions that can be generalized to similar research programs. It should be noted, however, that I am neither an academic nor do I have any experience managing university research.

The recommendations that follow are not simply steps that can be taken to improve management and coordination of research projects. They also include hints for increasing academic recognition and for bringing this kind of research, which tends to be isolated, into the mainstream of the institutional agenda.

1. Ensuring academic and industrial recognition

Academic research does not easily diffuse into practical application. MIT's auto program has been in the unusual position of making a profound impact on industrial practice while struggling for academic recognition. The tremendous acclaim that followed the book's publication has slowly made the internal opinion more favorable, but the program managers must share some blame for the delay in academic recognition for they did not stress the dissemination of research in academic channels. It was left to the whim of individual researchers. As many researchers were not looking for an academic career, the program managers probably did not consider academic recognition very important.

Program managers should expand the communication policy to address (1) industry practitioners, in order to influence industrial practice; (2) policy makers, in order to frame the issues and help develop solutions; and (3) academics, in order to contribute to curriculum development and the understanding of industrial practice within the university.

Program managers should begin to develop information for academic channels at the outset. The delay in reaching the academic audience not only deprives the research of making a timely impact, it also delays the recognition and rewards that can accrue to researchers associated with the program. In order to balance the needs of academia and industry, the program can follow a two-pronged publishing policy. The results from individual research modules can be published in academic journals, and more generalized articles that integrate research findings can be written for industry managers and practitioners. It is not difficult to implement this policy, which also addresses the need of researchers to publish in academic journals.

2. Obtaining the active involvement of senior faculty

Senior faculty involvement in the IMVP was mostly passive and indirect. The active involvement of senior faculty is extremely important for three reasons. First, tenured faculty can take more risks in developing research projects that are unconventional and that do not have a disciplinary focus. Second, they bring credibility and prestige to the program and thus ensure better infusion of research results into the curriculum. Third, as they are involved in framing university policies, they will be able to make sure the research has a more effective and timely impact on education and course development.

3. Preserving the character of academic enquiry

The interests of industrial sponsors are confined to their perceptions of what the important problems are. Therefore, although academics should consider sponsors' interests when formulating the research agenda, they also must ensure that the agenda is not limited by those interests. One way to do this is to focus on a set of outcomes or variables that are not necessarily those that any one sponsor would choose for researchers. One IMVP researcher explained:

> For example, even if a sponsor company is interested in productivity and quality, it might not have thought of exploring the human resource issues to the extent I was interested in exploring them. Thus the sponsor would have been content to have everything explained in terms of two or three variables that it considered most important, [and these variables] might not have even been consistent from one sponsor to another.

Other ways to protect research from too much industry influence are to include the interests of other stakeholders, like consumers, and to broaden the scope to cover societal issues that sponsors would not usually be interested in.

4. Protecting data

One of the key reasons that MIT succeeded in carrying out an industrywide study was its great access to information. Sponsors perceived MIT as an honest and impartial entity that would not use the information to their detriment. However, there were times in the IMVP when information leaked, mostly because of researcher naivete. Sponsors take confidentiality very seriously; mistakes can easily shut off access to information and facilities, endangering the research.

The IMVP assumed that the confidentiality rules were implicitly understood. <Author: But didn't researchers take a "confidentiality pledge"? I assumed this was in writing.> It

would be wise for programs to give a written policy to researchers before data collection begins and perhaps to have them sign a confidentiality contract. In the IMVP program, all researchers had access to all types of data. Program managers might also consider establishing rules to data access. Access to particular data should probably be limited to the primary researcher and the research director. If the data is to be used by many researchers, a coding system may be used to conceal sponsor identities.

5. Establishing a policy for post-program employment

The auto program is now seeing a turnover in the ranks of researchers. Sponsors are not concerned if researchers remain in academia, but they fear that those who accept employment within the industry will misuse the information. To set these fears to rest, program managers should formulate guidelines for post-program association.

6. Integrating faculty members and students from different disciplines <Author: I don't think that "Finding overlap and linkage with other special interest groups" adequately characterizes this section.>

Although MIT's engineering school has developed interdisciplinary educational and research programs internally and even established some educational programs with social science disciplines, research projects combining engineering and social sciences have not happened. The attempts of IMVP researchers to involve engineering faculty were not very successful. One faculty member and one graduate student group from the material science department did get involved. Perhaps individual efforts are not enough. An institutewide effort should be made to integrate research activities across engineering and humanities. Such activities will improve, not only management and management education, but conceptions of postmodern engineering and engineering education as well.

7. Strengthening the link between research and education

The ultimate objective of university research is to develop knowledge that can be imparted to students. Traditionally, the link between research and teaching has not been strong, and it takes a long time to translate research results into course material. But the university's research and education missions should not be compartmentalized; they should have a symbiotic relationship. Ways must be found to channel more research-derived knowledge into the curriculum -- and to do it faster.