Perspectives on Technology and Industrial Competitiveness: An Edited Transcript of an NAE Roundtable (1986)

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PERSPECTIVES ON TECHNOLOGY AND INDUSTRIAL COMPETITIVENESS

An Edited Transcript of an NAE Roundtable

PREFACE

This document is an edited transcript of portions of a National Academy of Engineering (NAE) roundtable presentation of perspectives on technology and industrial competitiveness. The purpose of the roundtable was to engage experts from a range of backgrounds on the topic with the hope that the insights and recommendations offered by the participants in the discussion would help in the formulation of NAE activities on industrial competitiveness.

Particularly interesting was the degree to which it became clear during the roundtable that the debate over industrial competitiveness is characterized by a variety of perspectives on sources of, and concerns with, U.S. industrial competitiveness. Though there was considerable agreement on some issues, there was also considerable divergence in approaches to the problem and what individuals saw as pressing issues. There was general agreement, for example, on the detrimental effects of high and rapidly varying capital costs, on the value of improvement in manufacturing technology, and on the need for better translation of research into commercial products and processes. There were, however, divergent views expressed about the relative importance of technology in enhancing national competitiveness.

On the one hand, there was the view that micro and macroeconomic factors (for example, interest rates, currency exchange rates, and tax structures) were the most important influences on national competitiveness. This view was usually accompanied by the opinion that it mattered little what particular activities—agriculture, manufacturing, services, or other—fueled the U.S. (or any) economy. On the other hand, there were equally strongly held views that advancing technology and its proper assimilation by management and the work force were essential to maintaining U.S. competitiveness in all sectors, and

especially the manufacturing industries. The latter view was also often tied to the belief that it is critical for the long-term health of the U.S. economy to remain competitive in certain basic and key manufacturing industries.

Though the discussion went on for most of a day, areas of consensus and divergence became clear during the opening session as each of the participants offered his or her individual perspective on key issues on the problem of U.S. competitiveness. The document that follows is a transcript of those opening remarks. Each of the participants has edited his or her remarks and approved them for publication. Held on January 7, 1986, the roundtable was chaired by Alexander Flax, Home Secretary of the NAE, and staffed by Bruce Guile, NAE Program Officer.

Alexander Flax, Home Secretary, National Academy of Engineering, (Roundtable Chairman)

I want to express my appreciation for your taking the time to join us for this one-day session. We have asked you here to help in a stock-taking for the National Academy of Engineering. This activity is important because of the questions we will be discussing and because a major focus of Academy activities over the next several years will be in the area of industrial competitiveness. We are interested in what the priority issues are and what we as an Academy can do.

It should be evident from the fact that we invited so diverse a group that we do not imagine that industrial competitiveness can be viewed solely as a problem in technology. As an Academy, of course, we have most leverage in issues of technology policy and other technological matters, but we recognize that technological advance is immersed in an economic, social, and political environment that influences industrial competitiveness.

We are not here to critique any particular program, but we would like to look at the issues in broad perspective. As is evident from the various papers and articles written on the subject, there are many viewpoints on competitiveness. The viewpoint of an individual firm on competitiveness is quite straightforward—survival. The viewpoint of an industrial sector is less clear, and the national viewpoint—if there is such a thing—is still another.

As an Academy, we are concerned with engineering and technology at all these levels, and we are also concerned about a broad range of sectors of application of engineering and technology. For example, we include agriculture, which, after all, is an area in which technological progress has been a major factor over the last hundred years. We are interested in the question of the service sector and what technology does or does not do there. And we are also well aware that within our total economy there is a military economy that has an important bearing on what goes on in the civilian economy. At some point, the Academy program has addressed or will address many of these areas.

With that, I would like to proceed to our discussion. I would like to ask the participants for their perspectives on the principal points of leverage on the problem of U.S. competitiveness. Recognizing that many factors are beyond the scope of NAE's own activities, we still need to be aware of them, so feel free to be wide ranging in your comments.

Bela Gold, Fletcher Jones Professor of Technology and Management, Claremont Graduate School of Business

Having studied these problems in a variety of industries, in Europe and Japan as well as the United States, I feel that there is no way in which you can offer a simple formula for improving competitiveness or even research and development activities. However, in my view, based on my own research, an important issue is the extent to which senior management in our companies has backed away from active support of basic research and its subsequent application. You can see this from what has happened to research budgets in a wide range of companies. You can also see it in the type of research being performed and the extent to which it

has become more and more concerned with applications, more and more concerned with short-term objectives. Consequently, much research is increasingly oriented toward catching up with, or making only some slight advance over, what others are doing.

The difficulty with this approach is that to develop and bring to commercialization major new technologies, you must work with a longer time perspective. If you concentrate basic research activities on shorter times and more-limited objectives, you will constantly be behind. Nevertheless, when you talk to senior officers of many U.S. companies, and raise issues of this kind, you discover that because of financial pressures—capital budgeting in particular—firms will not make major commitments to projects that will not come to fruition for three to five years. This is especially true of high-risk projects. If you combine a long time horizon with a high risk that a research project will not come to profitable fruition, firms will rarely invest. Such R&D decisions are made on the basis of current financial criteria for evaluating the allocation of resources and the form of the decision tends to be "not that, not now" or "maybe we could concentrate on something else."

My feeling is not that U.S. firms lack the capabilities down the line in various areas, or that they lack the commitment and drive on the part of most middle-level technical and managerial people. In my judgment, it is the senior officers of companies who should be more worried about these issues. When talking to them you do not get a sense of involvement, a sense of specificity of concern, with these longer term problems. You have to go down about three layers in the organization before you begin to find the people who are actively worried about providing the bases for regaining competitiveness. These people are deeply concerned with how they can get the company committed to urgently needed longer horizon investments in research and development.

I have done a good bit of research in Japan. A critical difference between U.S. and Japanese firms is that in Japan there is a basic commitment to building the firm's competitiveness five to eight years hence. Senior Japanese executives do not emphasize the issues of what the firm should be doing this year. Those are primarily lower-level concerns. In the steel industry, for example, Japanese firms are running at about 70 percent of capacity and yet they are still investing new capital in upgrading steel facilities. Why are they doing this when they have substantial unused capacity? They will tell you that their competitors elsewhere have already cut back on new facilities and new kinds of productive technology because of recession. But, they emphasize, such recessions are bound to end sooner or later. Hence, they are investing now, so that when an upswing comes they will be even farther ahead of their competitors in supplying low-cost, high-quality steel products. This illustrates an important difference in the decision-making horizons of U.S. and Japanese senior managers.

Richard Emmert, Vice President, Photo Systems and Electronics Products, E.I. du Pont de Nemours & Company

I agree that U.S. R&D and U.S. industrial objectives tend to be shorter term than those of some countries—most particularly, those of Japan. I think that the dominant reason for this difference is that the cost of capital is substantially greater in the United

States than it is in Japan—by a factor of two to three. There are several reasons for this, but the consequences are the important thing. The same discounted cash flow analysis of potential research investments will yield significantly different results in different countries, depending on cost of capital and on currency relationships. That is a major factor in the Japanese ability to focus on the long term by putting money aside today in the form of R&D, permanent investment, market development, or organization development. It is cheaper to them.

The numbers show that there is less industrial research done in the United States than in other major industrial countries as a percent of GNP. They also show that the research funded by the U.S. government is far more heavily aimed toward defense than is true in other countries. Much of the government-funded research in other countries is aimed toward development of industries to enhance trade balance and exports to a degree not so in the United States. Japan is an important example in this regard. Yet, generally I do not believe that the United States suffers from inferior technology. Other factors are more pertinent.

The chemical industry, for example, has the highest rate of research expenditure as a percent of sales among U.S. industries, and U.S. chemical technology has led that of other countries. Despite this leading technology, however, we are competitively disadvantaged because of the relationships among world currencies. We at Du Pont see direct evidence of this because we have facilities all over the world. We put identical technology in different countries yet find that competitive differences—ranging up to 35 percent on a cost basis—are not uncommon. They overwhelm the freight and duty costs and sometimes cause us to shut down facilities in various countries despite the use of the same technology and comparable or better worker productivity.

Therefore, in addressing technology and competitiveness, certain fundamental economic considerations must be superimposed on the technological and research policy issues. Fiscal policy affects many of the technological aspects of competitiveness dramatically. The domestic tax structure affects capital formation, and general fiscal policy affects exchange rates. Other countries that permit rebates of value-added tax to exported products at the border do enhance national exports and give an additional advantage to foreign-made products—beyond the currency relationships—in U.S. domestic markets.

Personally, I believe that although it is clear that this group should focus on technology-related issues, it is also important to identify the major social, political, and economic effects on technology.

Richard Messinger, Vice President, Research and Development, Cincinnati Milacron, Inc.

I approach the topic at hand from the point of view of someone from the machine tool industry; and from that perspective I believe the development and implementation of manufacturing technology plays a key role in our industrial competitiveness. More simply stated, our industrial competitiveness problem is our manufacturing competitiveness problem. Foreign manufacturers and universities have continued to focus on manufacturing technologies as a key element in their competitive strategies and thus have embraced and

implemented new manufacturing methods and machines sooner and more extensively than companies in the United States. In fact, in the United States, the situation was much worse as U.S. managers took our manufacturing capabilities for granted and thus, unintentionally, deemphasized its importance. Both the development and the implementation of new manufacturing technology is very important to our industrial competitiveness.

First, let us look at some of the problems related to the development of new methods and machinery. The machine tool industry, where most of these developments are done, is small, made up of many small companies. Even Cincinnati Milacron, the largest in the industry, is still a relatively small company compared with companies such as Du Pont. To put the machine tool industry into proper perspective, I recently heard it described as "one-fifth the size of the panty hose business." The industry also has the problem of being highly capital intensive, subject to low-volume production with low profits, and cyclical—a high-risk business, not the ideal environment on which to rely for the development of our next generation of manufacturing equipment. Even so, if you look at the character of our small industry, you will see that it has a major effect on U.S. competitiveness. Let me cite an example.

We were involved with Du Pont in the development of the process and machinery required to manufacture the new plastic for the soft drink market. The joint project cost over $20 million and took more than seven years to develop. The market was saturated with $75 million in machines capable of processing about $1 billion worth of plastic. Thus, you have the material suppliers on one end of the process supplying $1 billion per year of plastic and the converters, bottlers, and distributors at the other end adding about $1.5 billion per year of value; and in the middle, a little orifice of $75 million (one-time sale) in machines through which all this production passes.

Saying this another way, $75 million in machines, which are developed at high risk and cost, generated only a small profit for the machinery developer but created $2.5 billion in economic activity year in and year out. There is no way, from an economic point of view, for our industry to consistently put large amounts of money into research and development. We make the razor only—not the razor blades, where the development costs are large and the markets small. Without Du Pont's financial and technical support, we would not have taken the risk to develop this new manufacturing technology. Unfortunately, this type of involvement is the exception and not the rule. For this reason, our industry is sometimes unable to provide our customers a competitive advantage in manufacturing technology.

. . . the norm in U.S. firms is to have little technical capability on the plant floor.

It is difficult to expect companies to get involved in the development of new machines when there is little interest in implementing current technology. And that lack of focus on manufacturing has caused a second problem—the low level of skill and education among the users of machine tools. Industrial or manufacturing engineering is the lowest-status group of engineers in industry or academia in the United States. With the possible exception of graduates in chemical engineering, the brightest

young engineers out of academia do not go into manufacturing. They go into research and development, and marketing. U.S. manufacturing people tend to be self-educated or the products of two-year schools. As a result we are finding that the level of ability that many of our customers have in applying new technology is rather low.

Cincinnati Milacron through Eugene Merchant invested 20 years in trying to educate U.S. industry about the directions new technology is taking. The company sent Dr. Merchant around the world just to carry the gospel of technology in manufacturing. In 1968 we invested $10 million in the development of an automated factory. It was a technological watershed. Unfortunately the only companies I could get interested in that technology were German and Japanese. The risk of something new combined with the lack of knowledge on the part of the U.S. engineers who would have to apply the technology made the computer-integrated manufacturing idea particularly slow to mature in the minds of U.S. manufacturers. Also, the level of capability on the shop floor is higher in foreign countries than in the United States. Let me give you an example of an important cross-national difference.

Proctor and Gamble has set up a new disposable-diaper plant in Japan. They have B.S.-degree technicians running their plant, and the plant will continue to be operated by B.S.-degree technicians. They have a level of capability at the manufacturing levels of these plants that allows a rapid change of technology, whereas the norm in U.S. firms is to have little technical capability on the plant floor.

I think we need to change our educational programs and bring U.S. manufacturing engineering—which is a multidisciplinary function—into better focus. This is already happening, of course. Five years ago I could name only three or four universities that had what I consider top-rate manufacturing engineering activities. Today nearly all 200 engineering schools in the United States are asking for equipment and help. There is definitely a recent change of emphasis.

We do have to think about the cost and the length of time it takes to develop a new process, but we must also look hard at U.S. engineering education as a way of improving our manufacturing capability and our strength in adopting new technologies.

Dennis Chamot, Associate Director, Department for Professional Employees, AFL-CIO

I find that in discussions like this it is often useful to question conventional wisdom. Thus, I assert as a generality that technology is not the issue. I would say that for the short term—for the next two or three years—there is plenty of technology available.

In other words, basic research is not the immediate issue. We cannot look for new research breakthroughs to pull us out of our competitiveness problems. The basic research that we must depend on for industrial competitiveness in most areas has been done for some time. The basic research being done now is to guarantee success for the future but not to solve the immediate problem.

Am I arguing that we should cut back on basic research? Of course not. We need a healthy research base for the long haul, but I do not believe that the problems that we face in industrial competitiveness for the next few years are due to a lack of available technology or

a lack of new ideas out of basic research.

In some industries, of course, research is more relevant than in others. In the computer industry, for example, the large amount of basic research going on now is expected to be essential in guaranteeing success in products in just a few years. I am sure, however, that this is not true of the automotive industry, where the immediate future depends on new materials and manufacturing systems on which the research was done some time ago.

To me the question is, Why do some of our competitors apply the fruits of research so much more rapidly than we do in the United States? Some of these issues have been touched upon already, and I will not repeat them except to make one comment in support of a previous comment. I strongly endorse Bela Gold's comments about the short-term time frame of American management. I think that this is an important issue that has been discussed in the business community and in the academic community for years. It is hard to find people who disagree, but we do not seem to have changed our behavior.

We have to bear in mind that there may be differences in view and in goals between national competitiveness and corporate competitiveness.

We also need a greater commitment to people. Having stated that technology is not necessarily the major immediate issue, I would add that people are a major problem and issue. We have allowed our basic educational system to deteriorate disastrously. I am not referring to promoting additional fellowships for graduate study in engineering, much as that may be useful. I am referring to basic, fundamental education: teaching people how to write and communicate, how to think, how to do simple arithmetic, and how to deal with practical problems. As a nation we seem to be failing in this area.

Also, we need to think about different ways to treat people to promote their interests, not just those of the organizations they work for. Clearly, job security is an important issue. One major advantage that the Japanese seem to have is that they have a flexible work force. They can move people effectively from one job to another. That does not come as a gift from heaven. It is the result of direct policies the Japanese have pursued to invest heavily in on-the-job training and education, and to provide, for at least a small fraction of their workers, extraordinary job security, which reduces people's resistance to moving around. The resistance to change derives directly from insecurity, and if you lower that insecurity you will also lower the resistance to change. This issue applies to people at all levels, from the factory laborer, to workers at the more complex tasks in the factory, to the engineering work force, to middle management, and on up the hierarchy.

I would also like to comment on using a discounted cash flow to justify investments. If you cannot justify an investment on the basis of its return, yet your industry faces a threat to its survival five or ten years down the road, then I suggest that the economic theory has to be abandoned and be replaced with something else. I do not know what the alternative may be, but maybe firms demand too much of a return on investment, or maybe the Japanese are satisfied with a lower

return and as a result will get more of a market—more of a leg up.

Finally, I would like to comment on the general term "industrial competitiveness" in the sense of international competitiveness. We have to bear in mind that there may be differences in view and in goals between national competitiveness and corporate competitiveness. They do not always mean the same thing. Does it necessarily help American national goals for a company to develop technologies that are then put in place in a foreign manufacturing facility to import products to the United States? I am sure there are cases where the answer is yes, but you can certainly find cases where the answer is no. I think it is essential, if we are concerned about American competitiveness in an international environment, to consider the activities of multinational companies and recognize that economics knows no national boundaries. National boundaries, however, are important focal points for political and social concerns. National interests may not be served by a purely free market. There may be times when an open international marketplace should be modified to serve national interests.

Laura Tyson, Associate Professor of Economics, University of California, Berkeley

The way my colleagues and I have been thinking about the issue of competitiveness is really by thinking of productivity and relative productivity performance. If you take a long-term point of view and consider the poor performance of productivity growth in the United States over an extended period, technology and research become one of many inputs that affect productivity. Those inputs include capital formation; the quality, quantity, and flexibility of the labor force; and technological advance. This approach allows us to incorporate issues like the cost of capital, which affects the rate of capital formation, and the quality and amount of research and development, which affects the type and rate of technological advance. We should conceive of the problem of competitiveness as one of trying to improve the quality, quantity, and flexibility of the inputs to U.S. productivity growth.

I think that one issue that needs to be discussed today is the extent to which we agree that there is a competitiveness problem. Underlying this meeting is the assumption that there is a problem, and I believe there is a problem. However, one has to take seriously the view that if we were to adjust our tax policies, macroeconomic policy, and exchange rate policy—if we were somehow to get our macroeconomic story right—the competitiveness problem would go away.

If you consider the period 1980 to 1985, most of the economic evidence is rather compelling: a good two-thirds of our problem is the misalignment of interest and exchange rates and the underlying macroeconomic policies that affect interest and exchange rates. These factors have such a large effect that they have, in a sense, swamped everything else. We may find ways to improve research and development, to increase the rate of diffusion of technology, to educate better managers and better engineers, and to develop a work force with a desire to improve productivity. If, however, we do all those things and we still do not get an improvement in the macroeconomic situation—or if we get an improvement by a set of taxes or deficit-reduction measures that actually undermine our ability to encourage investment, under-

mine our ability to invest in education, undermine our abilities to sustain research and development—then we will not solve the competitiveness problem.

Among other issues that I think are important is that of services. Many people would say that there is a natural transition from manufacturing to services in an advanced industrial country. The argument follows that other countries have caught up to the United States in productivity and in manufacturing skills, and that this progression does not really matter to U.S. economic welfare because the "natural" future of the U.S. economy is in services. The argument leads to the conclusion that we need not worry too much about our industrial manufacturing base, or about the fact that our productivity levels are now matched or surpassed in certain industries by our competitors.

The question I think one needs to address is the extent to which we can sustain a service-based economy without a manufacturing base.

The question I think one needs to address is the extent to which we can sustain a service-based economy without a manufacturing base. What does a service economy mean? What kinds of services will be important and who will consume them? Much of what we commonly call services are simply inputs into the domestic manufacturing base. Since some of these services can cross national boundaries, we can become a service supplier to the manufacturing base of Japan, but we have to think seriously about how well that would work. Why would it not work? Where will it work best?

Another important issue in competitiveness is that of strategic industries. Do some industries matter more than others? I raise this question because the presumption among most economists—and I am an economist—is that it does not matter. That is, the United States may have a trade deficit problem, but, the logic goes, it can be solved if we can just export more oil to Japan, more oranges to France, or more coal to Poland. Economists assume that the market should essentially determine what industries we have and what industries we do not have, and that there is no particular strategic importance to any industry. Some recent reports support this view and argue that the United States does not really have a competitiveness problem. I think the analyses just raise more questions.

These reports argue that we have an exchange rate problem and a macroeconomic problem and that if we adjust our macro policies we will achieve a sustainable trade balance. The reports identify sectors where jobs were created or lost as a result of international competitive pressures during the 1970s and through the early 1980s. The reports do not address the significance of the sectors that lost jobs versus the significance of the sectors that gained them. Instead, the discussions focus on whether the number of industries gaining jobs exceeded the number of industries losing them or whether the number of jobs gained exceeded the number of jobs lost. The implicit assumption of such an approach is that when net job creation is positive, there is no need to worry about what kinds of industries are losing jobs or what kinds of jobs are being lost. But what if there is something strategically important about certain industries or certain kinds

of jobs in the sense that they are at the cutting edge of technology or that they affect the learning curve for the introduction of new technology. To understand the implications of the international competitive challenge for the future productivity and growth of the U.S. economy, we must recognize that certain industries are strategic and we must develop policies to support them.

Ian Ross, President, AT&T Bell Laboratories

(Dr. Ross was a member of the Presidential Commission on Industrial Competitiveness, which issued its report to President Reagan in January 1985.) The President's Commission on Industrial Competitiveness concluded that the United States leads other nations technologically, and that our technology is a major asset, but one we must continue to improve. What the Commission identified as the major problem is our manufacturing capability.

The Commission considered the biggest problem in industrial competitiveness in many sectors to be that we have let our manufacturing lapse. There was general agreement that a nation has to maintain its manufacturing base, just as it must maintain its agricultural base. Just because the agricultural sector employs only 3 percent of the work force does not mean that agriculture is unimportant. Just because changing technology is driving down employment in manufacturing does not mean that manufacturing is unimportant.

Additionally, of course, a comprehensive manufacturing capability is important to national security. It ought to worry us, for example, that effectively no liquid crystal diodes are manufactured in this country. Therefore, the Commission identified manufacturing as the main issue in competitiveness.

The Commission looked at the fact that the United States has high labor rates and considered that to be a national objective: we want a high standard of living, and we want to retain higher labor rates than our allies across the Pacific. The Commission recognized that the United States has high capital costs, that they are unnecessarily high, and that things can be done in Washington to make corrections. However, if we want to compete with overseas manufactures produced with cheaper labor, then we have to look to lower labor content. In some of the more advanced industries today—whether they be chemical industries or electronic industries—direct labor content can be reduced to less than 5 percent of the total value of the product. There is little need to worry about cheaper labor if such reductions are made.

What does it take to reduce the labor content of manufactured products? The most important thing is to invest in manufacturing technology and to invest in it for the long run. Most manufacturing technology is well developed, and most of it was developed in this country. Apparently, certain industries have chosen not to invest in the technology of manufacturing. That fact left the Commission with one dilemma to which it did not find a satisfactory answer. What are the factors that motivate the managers and the boards of directors of certain companies to look only at the short run rather than a balance between the short run and the long run? This is not a simple problem. It is easy to come up with reasons for concentrating on the short term, but it is hard to explain why—within the same economic, social, and political environment—some industries have done orders of magnitude

better than others. The semiconductor industry to date has done a fine job of investing in both manufacturing and R&D. The steel industry, on the other hand, has done poorly.

It is a complex issue, and countless factors, many of them economic, affect its resolution. If, however, we could get a better understanding of what it is that motivates industrial leaders to work for a proper balance between long-term and short-term investment, I think we would be doing much to address our industrial competitiveness problem.

George Eads, Dean, School of Public Affairs, University of Maryland

(On July 1, 1986 Dr. Eads was named vice-president and chief economist, General Motors Corporation.) What are we really after when we talk about competitiveness? The notion of competitiveness as an issue affecting individual companies or even a whole industry is pretty straightforward. Firms that are competitive tend to know it, and firms that are not competitive know it also.

When you address competitiveness as a national or international issue, it is much less well defined. At least some effort might be directed toward producing a better understanding of what we really should be after when we talk about the term *competitiveness*.

If we do not know what we are after, we will not know where we are when we have got it. One clearly cannot accept as a realistic goal of this kind of exercise to restore the United States to the level of dominance it held immediately following World War II, although some people propose this. Nor can one realistically propose that the United States establish positive trade balances with all of its major trading partners, because that is mathematically impossible. There is fuzziness in current thinking about how we would know when the United States was truly competitive.

It is important to know how to determine whether you are doing better or worse, and I think it is more than just productivity. To the extent that the cost of capital is a major factor in disadvantaging U.S. firms in competition with Japanese firms, the opening of the Japanese capital market is an important step in the right direction. It is a slow process and may never be complete, but to the extent that Japanese capital markets are open, and to the extent that we can get our macroeconomic policies in decent shape, much of the importance of national capital costs to international competition should disappear.

These two issues—how to open the world capital markets and how to reshape U.S. macro policies—are, in my opinion, more important than restructuring the U.S. economy to change capital costs. Frankly, there is no way to change the U.S. savings rate significantly. To increase the savings rate in this country would require changes that the public would most likely be unwilling to accept. It is nice to talk about raising the savings rate, but if you consider the incentives in Japan for high savings and ask if you would want to have those incentives exist here, the answer is no. An attempt to increase savings would involve radical changes in the way we provide for pensions and medical care, for example. It would involve, among other things, changing the consumer loan market so that the only way you could buy a house would be to make a much larger down payment than is now required. It is impossible to develop political support for such changes.

In the Japanese steel and electronics industries, the productivity improvements have come from what I call slight advances. That is, a sustained accumulation of many small improvements in technology or business practice over a long period of time has been the primary source of economic improvement in Japan. It seems that one disadvantage of the U.S. system is that our industries are looking to the big technological fix. We are trying to find the breakthrough that, if applied, would move us forward decisively. The Japanese model, on the other hand, seems to be to move along patiently, moving up the technology curve a little bit at a time. Over a period of 10 years, the total advance is much farther than you might think and competitively significant. This issue also goes to the heart of the question about the kind of people we train to do our basic engineering.

As a student of the history of U.S. technology between the Civil War and World War I, I interpret the technological changes in that period as a series of slight advances. The electricity industry, the steel industry, the railroad industry, and all the machinery industries in this country developed, in that post-Civil War period, by constant gradual improvements. Appreciation of the importance of slight advances accumulated over long periods of time is important. I think that this is related to the kind of training we give our engineers. Many engineers today seem interested in technology for its own sake, in part because they are trained in that tradition rather than in the older tradition of making it work and making something work better.

John Bollinger, Dean, College of Engineering, University of Wisconsin-Madison

In response to comments about the need for a definition of industrial competitiveness, I propose the following four-point description. First, companies competitive in the marketplace show their competitiveness by gaining market share. Second, to be competitive a firm must maintain not only market share, but also markets. Third, if a firm can achieve the first and second points *and* show that it is building for the future, then it is even closer to being competitive. Fourth, a firm must achieve the first three points and come up with an acceptable pretax profit. If a firm can do those four things, it is indeed competitive. Some companies do this very well.

There are three ways in which a firm gains market share: marketing, a technical edge in the product, or a price edge through efficient manufacturing. I will not address the marketing approach here because from a technological standpoint the other two means of gaining market share are more interesting. The technical edge in the product involves research or stealing, borrowing, or buying the technology elsewhere. The price edge through efficient manufacturing means that a firm did research in manufacturing or at least paid careful attention to the manufacturing processes they have. The margins that result from efficient manufacturing are a result not only of the technology a firm uses but also of the way a firm manages its human resources.

Demonstration that a firm is building for the future can occur in

many different ways. The percentage of gross sales that the firm spends on research is one measure of the firm's ability to turn that basic research into a product. One way to look at the issue is to think of all the products in the marketplace as having some life cycle and then to evaluate whether a firm is building for the future by considering the percentage of products that are in the beginning stages of their life cycle.

Finally, I would like to address briefly the maintenance of an acceptable pretax profit. In particular I would like to focus on the difference between public and private companies and the decision processes that drive management decisions in both cases. In a private company that is doing well, the management decision process is not driven by the institutional investors' behavior or the stock price, whereas in a publicly held company the opposite is true. In a public company, investment in the long-horizon future may reduce short-term margins and drive the price of the firm's stock down. As a result, the threat of acquisition becomes greater as the stock price reflects low short-term returns while the long-term strength of the productive assets increases. Public companies are constrained in their investment behavior in ways that private companies are not.

These four points then—maintaining market share, finding new and growing markets, planning for the future, and sustaining a profit—provide a framework for considering several competitiveness issues.

Dale Compton, Senior Fellow, National Academy of Engineering

(Dr. Compton is former vice president, research, Ford Motor Company.) I would like to make comments from two perspectives—first, from the perspective of my past association with Ford Motor Company, and second, from the perspective of the Academy and its possible role in the study of industrial competitiveness.

I resonate strongly with some of the comments of earlier speakers. George Eads's comment about how the Japanese have been so successful in accumulating small gains is clearly true, at least as viewed by the automotive industry. Laura Tyson's comment about productivity, I think, gets to the heart of how you should measure how well your company is doing. Finally, I agree with Dennis Chamot and Ian Ross that U.S. technology is adequate but that we need better application.

Regarding our competitive position with respect to Japan, we should be aware of the relative level of overhead in U.S. and Japanese industries. The automotive industries in the two countries are a good example of the problem. In terms of the total number of hours of labor per automobile produced, the Japanese have a substantial advantage. If, however, you look at the number of direct hours used in producing an automobile, the situation in the two countries is about the same. It is the amount of the indirect labor that is driving our productivity down. Our additional financial and legal personnel, our labor classifications, combined with a much more formal corporate structure, drive our costs up. If this is a generic problem, there might be something we can do as an Academy to look at it in a way that would help U.S. industry restructure. Are there incentives that could be provided through government action, or is it entirely within the domain of individual companies?

A second comment about the automotive industry is that I agree that stability of the labor force and employment security are important issues. Even in Japan, however, the benefits of job security are largely limited to the upper tier of companies. A considerable proportion of every Japanese car is produced in factories employing people who have few benefits and no employment security. The real wage rates of this part of the Japanese work force are so low that I doubt that we would want to emulate this practice. The degree of disparity in the standard of living among people working in various companies within the same industry would seem odd in the United States.

I would like now to raise two specific questions. First, would there be value in the Academy's examining the issue of increased cooperative research among industrial competitors? We must recognize that technology is a worldwide commodity and that we are not going to control it nationally. Therefore, we need to manage our companies in ways that achieve competitiveness within this constraint, as well as within the constraints arising from the financial and economic environment. What would be the benefit, if any, from more cooperative research? How much would it cost and what incentives might be needed to make it happen? Certainly, if you look worldwide at the level of cooperative research, as distinct from cooperative development, it is substantially higher among many of our industrial competitors.

The second question is whether this Academy can usefully address the federal government's role in setting somewhat broader objectives for technological and industrial development. This relates, in part, to the question of strategic industries and technologies. What role, if any, should the federal government have in support of particular industries or technologies?

James Coleman, Professor, Department of Sociology, University of Chicago

I will comment briefly on education in mathematics and science in secondary schools in the United States. There have been some international comparisons of mathematics skills among 13 and 18 year olds, and science achievement at ages 14 and 18, and the United States does not show up well among developed nations in either area. Nor has mathematics education and science education improved in recent years. In the decade of the 1970s, there were declines in the number of courses that students were taking, or in the level of the courses, or in student achievement.

Nor is the situation better in private schools. Unless the private school is exceptionally good, a child will probably receive a worse education in science and mathematics there than in a good public school. Private schools in the United States tend to be especially good for humanities and literature and foreign languages and history, and not as good for science and technology.

Now to other points: As stated earlier, there is an extraordinary change going on in the structure and amount of international trade. To repeat, there is an extensive increase in the international flow of capital, the international flow of products and components of products, but there is not an international flow of labor, nor is there an automatic adjustment of the exchange rates to create trade balances. Those two exceptions make matters much different than they would otherwise be.

If there were an automatic adjustment in exchange rates so that we were not in a trade deficit but had a level trade balance, then we would necessarily have a comparative advantage in some exported goods, because a nation could not import greater value than it exported. As an example of the interdependence of different commodities, when Britain became an oil exporter because of oil discoveries, that hurt British industry by increasing the value of the pound, making British industry less internationally competitive. But such interdependence only occurs when exchange rates adjust to bring about trade balances.

The change in structure and amount of international trade means that there will be a great change in every country, or in developed countries, in the structure of industry. The United States will have a less diversified economy, perhaps more diversified than some other countries because of a larger internal market, but countries will specialize much more than in the past. The question is, What will be the basis of that specialization? I suspect that the basis of the specialization will not be the labor content of the industry because, as has been said earlier, in some areas direct labor content is driven down to a small fraction of the total value.

The problem was not the absence of technological innovation itself, but the movement of new technology into production.

Between the years of 1973 and 1983 I was a member of the General Motors Science Advisory Committee. The six of us who were on that committee gained a fascinating view of the technological and management problems that GM had during a period when the Japanese threat was particularly serious. It seemed again and again that the organization's problem was not the absence of technological innovation itself, but the movement of new technology into production. The problem lay in the incentive structure that existed for persons in middle levels of management. For example, McPherson struts were invented by a Chevrolet engineer but were never used at GM, even when GM began to build small cars, until the competition forced them to do so. The question that always arose in the committee was why innovations—like McPherson struts—somehow get bottled up at certain points. The answer always pointed to the question of incentive structure. How can incentive structure be changed so that technological developments are moved into actual developments in the product itself?

In trying to answer this question, I came to the conclusion, a conclusion that was not shared by all members of the committee, nor by some of the people at GM, that one thing that should be looked at seriously is property rights to innovation, and the possibilities of changes in property rights. As things stand now, firms have full property rights with respect to innovation. I think there should be an examination of change toward joint property rights between a group or an individual who carries out the development and the firm that employs them. There are already developments in American industry moving in that direction. An example is provided by the recently invented term *intrapreneurship*, meaning some kind of entrepreneurial activity that is generated within the firm. Some

firms—3M is a good example—develop spinoffs of various sorts and do give some kind of semi-property rights to people who create them. If one looks at the explosive growth in the area of technology, in Silicon Valley and comparable areas, the mobility between firms there has in effect created a *de facto* change in property rights. Persons carry with them to another firm, sometimes illegally, information that they get from or generate within the firm that employs them. This ability of the individual to capture part of the value resulting from his innovations may sometimes be harmful to particular firms, but it has been a great stimulus to the industry as a whole.

The general point is that there can be a great stimulus to innovation purely through a change in the allocation of property rights to innovations that arise within firms.

Robert Lawrence, Senior Fellow, The Brookings Institution

In my view there is no single concept called competitiveness and, as a consequence, much of the debate over competitiveness is misfocused. Competitiveness resembles a word like "love" or "democracy"; it means more or less what people want it to mean. I find, however, that there are three distinct notions of competitiveness.

First, our use of the word "competitiveness" often connotes "comparison." How does the United States compare with other nations? This notion has little or nothing to do with performance in international trade. We take certain criteria that we consider desirable objectives for an economy—most noteworthy and commonly used would be output per man-hour or total productivity—and then compare how we are doing in relation to other nations. Of course, when we ask these comparative questions on a number of criteria, particularly productivity, we find that our rate of change has not been as rapid as that of other nations. Broadly speaking, we still find that our total output per man-hour is generally higher—certainly in manufacturing—than in other nations, but the rate of increase in productivity is slower.

A second concept of competitiveness relates to U.S. performance in international trade. There is a tendency to assume a direct relationship between productivity and performance in international trade. This direct relationship may or may not exist. If an increase in productivity is reflected in higher profits and higher wages, it may have no effect on costs. Only to the degree to that productivity lowers prices or improves quality will it actually manifest itself in improved performance in international trade. There is a tendency to assume that the slowdown in U.S. productivity growth has an automatic effect on U.S. trade performance. This does not necessarily follow.

You could, of course, set up a paradigm in which exchange rates would clear markets to balance trade. In fact, I think that exchange rates clear markets to bring trade flows into line with differences in national spending patterns. Fundamentally, the United States has changed its spending patterns to the point that it is a large borrower from the rest of the world. In other words, I believe that exchange rates equilibrate not to bring trade into balance with relative productivity, but rather to bring our trade performance into line with our spending patterns. If we do not like the movement in our trade balance, we should look to our national spending patterns.

The third notion of competitiveness, which I think is the most important, has to do with efficiency. Are we doing the best we can? This, to me, is the crucial question. Addressing efficiency directly causes the other factors to fall into place. Many of the approaches that other countries try may be good for them but not for us. These approaches may worsen our efficiency rather than improve it. Regardless of whether our trade balance is positive or negative, or whether our trade share is increasing or decreasing, the crucial issue is whether we are doing the best we can. That question, ironically, focuses not on international comparisons or on trade, areas that seem to have mobilized us, but on domestic issues. When we consider the rate of growth in U.S. productivity, evidently we are not doing as well as we used to. In my view, it is unfortunate that we have dwelt on what we think are the international ramifications of that process. If we are doing the best we can, our exchange rate may have to devalue further to bring our trade into line. We should not be too concerned about our exchange rate since it operates independently of U.S. policy. We should worry, however, about whether we are doing the best we can. In many areas it seems we are not.

I would like to address another issue that involves the question of time horizons. Many people have argued that American management is shortsighted and that this shortsightedness is a fundamental failing in U.S. business. I am skeptical that American management is indeed shortsighted. I do not find this conventional wisdom convincing. Consider the performance of American multinational corporations around the world. These are companies that respond to incentives within the U.S. domestic capital market and whose dominant shareholders are in the United States. U.S. multinational corporations, as shown in studies by Robert Lipsey and Irving Kravis, suffered no erosion in market share globally throughout the late 1970s.* Although the United States may have lost market share as a location of production, the companies controlled by American managers have not lost market share. Clearly, American managers cannot be too shortsighted.

Also, I must say that I think the effect of capital costs on U.S. competitiveness is exaggerated. I am not convinced by the evidence. In fact, the Japanese capital cost system and the Korean capital cost system are really no more generous than that of the United States. It is true that American and Japanese firms' financial structures and reliance on debt and equity, differ substantially. Making some assumptions, people infer that the cost of capital is much cheaper to Japanese firms than to American firms because Japanese firms have far more debt. Nonetheless, if you look at capital formation within the manufacturing section, you do not find that the capital stock in American manufacturing, between 1975 and 1980, or even more recently, has grown more slowly in this country than it has in Japan.

With respect to research and development spending, a lot depends on how you interpret the data. First, I disagree with earlier comments that American manufacturing has been lax in commitment to R&D over the last few years. Private R&D spending in this country has kept pace with the R&D spending financed by the government on defense—5 or 6 percent in real terms. In every U.S. industry, you find a growing percentage of sales spent on R&D over this period. It is true that if you look at

* See, for example, Robert E. Lipsey and Irving B. Kravis, "The Competitive Position of U.S. Manufacturing Firms," National Bureau of Economic Research Working Paper 1557 (Cambridge, Mass.: NBER, February 1985).

civilian research and development as a proportion of total GNP, you will find that U.S. expenditures are low relative to other nations. This, however, is partly a function of our large services economy. If you examine what proportion of value-added is being spent on research and development, you do not find a major difference between the commitments of American companies and those around the world.

To take a long-term perspective in the U.S. economy, where the exchange rate and cyclical performance have fluctuated greatly, would be lunacy.

So, in terms of the commitment of inputs into investment and into research and development, and in terms of the output performance overall, I am not convinced that U.S. business managers are shortsighted. Let me take this issue further. We have to ask ourselves, in what environment does American management find itself. To the degree that people do pay attention to short-term factors, people do not behave simply out of whim. Why are they shortsighted? In my view, again, their behavior relates to the macroeconomic environment in which they find themselves.

If you have lived in a Japanese economy, with an exchange rate undervalued for two decades or more, you can take a long-term perspective. That is a logical and appropriate response. If you have lived in an economy like Japan, whose growth rates have varied between 4 and 6 percent since 1975 you can afford to borrow with more debt, and again, you can afford to plan with stability.

To take a long-term perspective in the U.S. economy, where the exchange rate and cyclical performance have fluctuated greatly, would be lunacy. You would be driven into bankruptcy in the next recession or in the next real rise in the exchange rate. Short-term attitudes are an appropriate response to this macroeconomic environment.

With regard to the question of strategic industries, I am skeptical about arguments concerning the need to sustain particular industries for strategic reasons. The word "strategic" is used in two senses. One is national defense, and I do believe that we may need industries for national defense. There is no reason why the free market is going to set us up perfectly to meet our defense capabilities. I think the efficient response to that need is to instruct the Department of Defense to take care of defense strategy. Let the budgeters debate whether they need another steel mill or a stockpile, as opposed to another tank or bomber system. I think that when we try to promote an entire industry because of its national defense ramifications, we get extremely inefficient policies. I accept the narrow notion of strategic industries with regard to defense. But I do not interpret the argument for defense-related strategic industries as justification for trade protection or for the support of entire industrial sectors. I have serious doubts about the broader question of industrial support for non-defense purposes.

Also, I am not worried about service jobs depending on manufacturing jobs. Manufacturing output in this country has grown as fast as gross national product. Today we are no more a services economy, as determined by services' share of the GNP, than we were in 1960. Goods output in this

country, despite the strong dollar, has increased as fast as services output since 1980. To the extent that jobs in services depend on output, on the actual performance of manufacturing tasks, the United States is not in trouble, since manufacturing output has continued to grow remarkably despite an unfavorable exchange rate.

Let me conclude by saying that I think that questions about the diffusion of technology and about the training of manpower are appropriate ones for the Academy to focus on. On the issue of education, I would add, we must pay attention to on-the-job education mechanisms. We have the advantage of a highly mobile labor force in this country, but in my view there are both good and bad effects of a mobile labor force. In particular, a mobile labor force reduces firms' incentives to engage in on-the-job training themselves because they lose the benefits. A strength of the Japanese system is that the Japanese can afford to take a long-term perspective in investing in their manpower, because they know the manpower is going to be around. I believe that the federal government can play an important role in encouraging on-the-job acquisition of skills that are transferable. When manpower circulates, it makes new skills available in the future.

Richard Morse, Corporate Director

(Dr. Morse was formerly Assistant Secretary, Army (R/D) and a Senior Lecturer, Sloan School of Management, MIT.) This is one of the few Washington meetings I have attended in the last 40 years or so where we are not suggesting that our problems will be solved by spending more money on research. There appears to be a consensus that this country has an abundance of advanced technology and basic research. Other factors account for our inability to compete in the world marketplace in many product areas and use our technology more effectively.

My concerns center on *people* and the *management* of technology. If one deletes the growing service business, and the large number of small companies, this country now has three industrial sectors: new technical enterprises; established companies like Du Pont or General Electric; and the aerospace and defense industries. Each sector is distinct in management style, corporate environment, and structure.

The generation of new technical enterprises has given Massachusetts the lowest unemployment rate in the country. Venture capital is now a mature business, and better firms are run by real professional managers. Venture capitalists are spending time putting out fires in investments made some years ago, but there is no lack of money for investment in new technology with good management talent. Attractive new enterprise investment opportunities, including start-ups, are recently more available in increasing numbers.

We ought to give the government a pat on the back for initiating the Small Business Innovation Research Program. This program is an effective mechanism for the support of innovative technology in small companies. This is one of the best ideas that the government has implemented to enhance the commercial development of new business enterprises.

In the new-enterprise sector there is a great discrepancy in geography. We have vast areas of the United States where there are almost no new technical enterprises. I do not believe there are neither innovative people nor potential entrepreneurs in the many areas that lack the educational and financial en-

vironment essential for the launching of new ventures. It is perhaps worth considering how we can encourage the spread of the new-enterprise phenomenon outside of Silicon Valley in California and Route 128 in Boston. This would not be an easy project, but we now know much more than we used to about the process of new enterprise generation.

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It is difficult for a small U.S. company to get established and sell its products in Europe or Asia. New mechanisms, such as some form of export sales corporation, are needed to help small ventures market abroad. The Japanese have their large trading companies that are very effective in marketing their products worldwide.

Another front on which to promote new-enterprise generation and the development of entrepreneurs is through education. For 15 years, as a faculty member of the Sloan School of Management at MIT, I ran a course known as New Enterprises. It attracted graduate students who might not have gone into new ventures if they had not taken the course. Many students later either started new technical business ventures or entered the venture capital business. Robert Swanson, for example, joined a venture capital firm and then founded Genentech, now a leader in the great field of genetic engineering. Our university community has a role in more effectively supporting the generation of new enterprises and developing a better understanding of the entrepreneur, management of small companies, and the venture capital business.

Many of our more innovative large companies are trying to capitalize on the high technology and innovative ideas to be found in small companies. This is not easy. The kinds of nontechnical people that run many big companies are not innovative, and their corporate structures are totally incompatible with a small company. A major industrial company, recently listed as "innovative" based on a poll of 8,000 people, spent more than $1 billion through a new venture subsidiary in an effort to generate new business enterprises. They had 100 percent failure in this activity. That is hard to do. All the entrepreneurs left the enterprises, and the venture capital community had so many bad experiences that they would not work with the new venture subsidiary. As a director of two of those ventures, I saw the total incompatibility of the large company's operating methods with the small company environment. Small technical enterprises are completely different from large corporations. Management skills, layers of legal talent, and the long-range planning required in a multibillion-dollar company are not compatible with the entrepreneurial style of a small venture.

Many of our large companies cannot attract innovative people. Some time ago a group of experts tried to identify the most innovative and least innovative companies in the country. Groups of students responded to the question of whether they would take a job or interview with the same companies. No students were interested in interviews or jobs with companies they thought to be noninnovative. They all wanted to work with the innovative companies. The problem of unimaginative management perpetuates itself. Without innovative

people at the top, a company cannot attract innovative people at any level. This degenerative process results in an organization totally unable to compete in a rapidly changing technological environment.

Many major corporations recognize the problem of developing innovative ideas within their corporate structure and are now sources of venture capital for small companies. If the corporation can help the new enterprise with management, engineering, and manufacturing or marketing expertise in addition to the supply of capital, this is often a useful arrangement for both parties.

It is difficult to divorce the characteristics of the large corporations from the unique management skills and the environment required for a successful venture capital operation. At least one oil company has tried the interesting experiment of using an innovative "high-tech" company to manage its venture operations such that each party shares in the resulting investments.

It has been said that a corporation is the reflected image of the individual at the top. Until the directors of America's industry assume the responsibility and obligations of their job and demand that CEOs have the characteristics needed to operate in a changing technological society, American companies will not be competitive in the changing world marketplace.

Large company management *can*, of course, be innovative. 3M is a good example of a firm that attracts innovative people. Unlike many other companies, the environment at 3M is such that if you have a new idea there is a mechanism within the corporation to try it out. The company wants new products and knows that its future depends on keeping the right climate for their generation.

Years ago, I had a small joint venture with 3M in the vacuum deposition of metals. On my first visit to 3M, the president said he wanted to have lunch with me. I was not even seated at the table when he said, "Okay, what's new in Boston?" This was the president of a large corporation and I was only the president of a small "high-tech" company. He had only one interest: What is new in technology? I do not know how you provide that atmosphere in a big company. You certainly will not accomplish it, however, if the CEO spends his time on mergers and acquisitions or the current corporate "restructuring" business with golden parachutes for executives.

I am concerned with the aerospace and defense sector and its adverse effect on our economy. Since we have about half of the technical professional people in this country now on the federal payroll, I like to look at this from the point of view of people, rather than the budget deficit. Technical people who know only the aerospace and defense industry become almost unemployable in the commercial sector. They do not know commercial product design, consumer styling, low-cost manufacture, or international marketing. They have none of the characteristics that you need to take on the Japanese. This, I think, is a national problem that ought to be faced, and a more serious problem than people are willing to admit. Our congressmen, instead of lobbying to get contracts from NASA or the Department of Defense in their districts, should recognize the long-range harm these can do to a community and the country.

Other than Boeing and one or two others, few aerospace companies have successfully converted their technology from defense to large-scale manufacturing of commercial products. Some of the claims made in support of NASA

programs regarding the commercial spin-off from manned space activities are questionable. NASA, for example, had nothing to do with the invention of Teflon, metalized Mylar, or Velcro—though they are often cited as NASA developments.

Finally, we ought to examine our government laboratories, many of which do commercial research and development in direct competition with industry. This is wrong. I am not suggesting shutting them down—they are an important national asset—but we need stricter guidelines for the way in which they operate. Argonne Lab should not design, build, and sell superconducting magnets or develop storage batteries for commercial purposes. Oak Ridge should not try to develop gas-fired home-heating systems, and Livermore should not try to develop new automotive engines. Our government labs should get out of commercially oriented research and use their expertise in new technology of direct and unique interest to federal programs. Ways might be found to employ the fine people and facilities of our national labs—as an aid to all levels of education. Indeed, until we enhance the quality of science and engineering education at all levels of society—from grade school to CEOs and congressmen—we will never solve our problem of industrial competition from the growing number of technology-oriented nations.