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ABSTRACT

Within this document is testimony delivered by seven individuals at a Congressional hearing on what role government and education should play in revitalizing U.S. productivity. Of particular interest at the hearing was a study made by the Massachusetts Institute of Technology (MIT) Commission on Industrial Productivity entitled "Made in America: Regaining the Productive Edge." The statements from members of Congress are from Edward Kennedy (Massachusetts) and Claiborne Pell (Rhode Island). Other statements are from Michael L. Dertouzos, professor of electrical engineering and computer science, director of the MIT Laboratory for Computer Science, and chairperson of the MIT Commission on Industrial Productivity; Richard K. Lester, associate professor of nuclear engineering and executive director of the MIT Commission on Industrial Productivity; Suzanne Berger, professor and head of the Department of Political Science, MIT; Richard Kazos, researcher and doctoral candidate; and Robert M. Solow, professor of economics, Nobel Laureate in economics, and vice chairperson of the MIT Commission on Industrial Productivity. (CML)

S HRG. 101-91

RESTORING AMERICAN PRODUCTIVITY: THE ROLE OF EDUCATION AND HUMAN RESOURCES

HEARING

BEFORE THE

COMMITTEE ON LABOR AND HUMAN RESOURCES UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON

EXAMINING THE ROLE OF EDUCATION AND HUMAN RESOURCES IN RESTORING AMERICAN PRODUCTIVITY

MAY 3, 1989

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STATEMENTS

WEDNESDAY, MAY 3, 1989

RESTORING AMERICAN PRODUCTIVITY: THE ROLE OF EDUCATION AND HUMAN RESOURCES

WEDNESDAY, MAY 3, 1989

U.S. SENATE,
COMMITTEE ON LABOR AND HUMAN RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 2:37 p.m., in Room SD-430, Dirksen Senate Office Building, Senator Edward M. Kennedy (chairman of the committee) presiding.

Present: Senators Kennedy and Jeffords.

OPENING STATEMENT OF SENATOR KENNEDY

The CHAIRMAN. We will come to order.

Yesterday, the MIT Commission on Industrial Productivity released its study "Made in America: Regaining the Productive Edge." The study is the result of two years of intensive analysis, and it provides an impressive call to action for American industry, Government, and the academic community.

The message is a warning to us all: Our economy is stagnating and our standard of living is declining because we are losing the markets of the world. Our foreign competitors see that America is a wounded economy. We can no longer afford to sit on the sidelines and accept our decline. It is time for the American economy to go on the offensive, again, as we have before at critical moments of our past.

The key players in this contest are our people. They must be in top shape, prepared to give their best effort They must be taught better skills from the earliest years in the schools, and they must have the most up-to-date training on the job. We must have a renewed spirit of cooperation between coaches and players, and we must be planning ahead and sparing no effort to develop the best possible game plan.

The report makes clear that our team must include players from Government as well as business A public-private effort is our best hope for success. We must reject the laissez-faire ideology that would mean Government watching helplessly from the grandstand. Government has a legitimate and important role in solving our problems and improving the lives of our people

The report details the consequences of our decline in productivity and prescribes a key role for both Government and industry in reversing that decline. The call for action by Government falls squarely within the agenda of the Labor and Human Resources Committee education, job training, scientific research, and man-

agement and labor relations. No challenge before this committee is more important Our committee must offer affordable new responses to this crisis. We must challenge Congress and the executive branch to work with us to make these solutions happen now before it is too late.

In this hearing today, we will concentrate on the role of Government and the responsibility of our committee.

As the report states, "It is no mere truism that the ultimate resource of an industrial economy is its people. One of the most disturbing ways in which the United States has lately fallen behind other nations is in developing and nurturing the skills of its people."

A major cause of this failure is our neglect of education. In a recent survey of eighth graders, American pupils ranks last of 12 countries in math, and ninth in science. Less than half of all U.S. high school students take math or science courses after the tenth grade. And literally thousands of our current secondary school math and science teachers are not qualified to teach their subjects.

At the college level, only six percent of the American undergraduate degrees are in engineering, versus 20 percent in Japan and 37 percent in Germany. In graduate school, more than 50 percent of the engineering doctorate degrees earned in American universities are awarded to foreign students. If present trends continue, the Nation faces a shortfall of over 500,000 scientists and engineers by the year 2010.

Education is the key to meet these challenges. As the report specifically states, upgrading elementary and secondary education is "probably the single most important challenge facing the nation."

Education is primarily a State or local responsibility. But we must continue to devise ways in which the Federal Government can help States, communities, college, and private firms upgrade and increase their education and training programs.

Most Members of Congress recognize the importance of investing in education. We stand ready to work with the Bush administration and develop these priorities. In this Congress, the Labor Committee is already considering legislation in critical areas, such as early education, vocational education, job training, teaching, and math and science education, and look forward to working closely with the administration to develop a coordinated approach capable of meeting this challenge.

[The prepared statement of Senator Kennedy follows:]

from the office of

Senator Edward M. Kennedy

of Massachusetts

STATEMENT OF SENATOR EDWARD M. KENNEDY
ON RESTORING AMERICAN PRODUCTIVITY:
THE ROLE OF EDUCATION AND HUMAN RESOURCES

For Immediate Release:
May 3, 1989
CONTACT: Paul Donovan
(202) 224-2633
Robin Buckley
(202) 224-4781

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The key players in this contest are our people They must be in top shape, prepared to give their best effort They must be taught better skills from the earliest years in the schools, and they must have the most up-to-date training on the job We must have a renewed spirit of cooperation between coaches and players, and we must be planning ahead and sparing no effort to develop the best possible game plan

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In this hearing today, we will concentrate on the role of government and the responsibility of our committee

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A major cause for this failure is our neglect of education. In a recent survey of 8th graders, American pupils ranked last of 12 countries in math, and 9th in science. Less than half of all U.S. high school students take math or science courses after 10th grade And literally thousands of our current secondary school math and science teachers are not qualified to teach their subjects.

At the college level, only 6% of American undergraduate degrees are in engineering, versus 20% in Japan and 37% in Germany. In graduate school, more than 50% of the engineering doctorate degrees earned in American universities are awarded to foreign students. If present trends continue, the nation faces a shortfall of over 500,000 scientists and engineers by the year 2010.

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Administration and develop these priorities In this Congress, the Labor Committee is already considering legislation in critical areas such as: early education, vocational education, job training, teaching, and math and science eduation, and look forward to working closely with the administration to develop a coordinated approach capable of meeting this challenge

Our witnesses today are members of the MIT Commission on Industrial Productivity. We welcome Michael Dertouzos, Chairman of the Commission, who will summarize its findings and describe the crisis in detail. Next will be Richard L. Lester, Executive Director of the Commission who will focus on the link among education, training and productivity. Next will be Suzanne Berger, Chairman of the Political Science Department and member of the Commission who will focus on K-12 educat on and on job training. The final witness will be Professor Robert Solow who will discuss our investment in research facilities and personnel and increasing the efficiency of military R&D.

At other critical moments in the past, we have recognized such challenges and met them successfully Our ancestors were not timid and America thrived. From the days of the American Revolution to modern times, we have never been content to settle for less than the best.

But many nations today question whether America still has what it takes. Can we summon the will--private initiative and the public leadership--to prove the handwringers wrong, and triumph again? The American people are waiting for an answer.

The CHAIRMAN. We will insert in the record at this point the opening statement of Senator Pell.

[The prepared opening statement of Senator Pell follows:]

OPENING STATEMENT OF SENATOR CLAIBORNE PELL

Senator PELL. Mr. Chairman, I want to thank you for holding this hearing. I thought our last hearing was extremely informative, and I look forward to an equally productive one this afternoon. I would like to commend the members of the M.I.T. Commission on Industrial Productivity, some of whom are with us this afternoon, for their focus on the importance of education. One of the conclusions drawn in their "Made in America" report clearly underscores a statement that I have made many many times in this Committee Room, that the real strength of our nation is measured not by the sum total of our weapons of destruction or our weapons of construction, nor by the amount of gold in Fort Knox Rather, it is determined by the sum total of the education and character of our people.

It was with this philosophy in mind that we crafted the educational titles of the Omnibus Trade Act last Congress. Through that Act, we provided major increases in existing educational programs where there is a clear linkage to economic growth and competitiveness, and created a series of new initiatives in areas such as technology and international understanding which will serve our nation well.

I welcome the voices of these authors here this morning as they join us in calling for additional investments in education, and I look forward to their comments today.

The CHAIRMAN. Our witnesses today are members of the MIT Commission on Industrial Productivity. We are very pleased to welcome Michael Dertouzos, a professor of computer science and electrical engineering at MIT, appointed chairman of the MIT Commission on Industrial Productivity by MIT president Paul Gray, and the principal author of "Made in America." Let me join in extending a personal word of welcome to you as well, Professor. I appreciated your comments and guidance on other occasions. We very much welcome you here today.

It is kind of an interesting phenomenon that we are debating the budget resolution over on the floor of the United States Senate even as we are here. And where we had been able in this budget resolution to see some very modest increases in the functions related to education, it still is incremental compared to the type of challenge that you pose.

I think that money in and of itself is not the answer. If you were to ask most Americans, what percentage of the national budget of one trillion, two hundred billion dollars is spent on education, that they would give an answer substantially higher than the actual 3 percent. To the extent that money is a reflection of priorities, I believe that most Americans would believe that education rates much higher than 3 percent.

We are reminded in the last ten years we have seen an increase in the cost of college education of about 42 percent and probably about a two percent increase in real dollars in all the range of dif-

ferent programs to help young American attend higher education. I think all of us are mindful, whether it is in Massachusetts or many of the other States, with the increasing budgets that the States are facing, their squeeze is being reflected in these education budgets.

In too many instances, I know, in our own Commonwealth, we are seeing those programs that were targeted for exceptional children in math and science squeezed out, the very things that you are talking about here. So it is an enormously important message that you give, and hopefully we will be able to respond to it in a positive of way. We have every intention in this committee to do all that we possibly can in reviewing the excellent recommendations and suggestions to see how we best can work to respond to those challenges.

We are very glad to have you here, as well as your colleagues.

STATEMENTS OF DR. MICHAEL L. DERTOUZOS, PROFESSOR OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE, DIRECTOR, MASSACHUSETTS INSTITUTE OF TECHNOLOGY LABORATORY FOR COMPUTER SCIENCE, AND CHAIRMAN, MASSACHUSETTS INSTITUTE OF TECHNOLOGY COMMISSION ON INDUSTRIAL PRODUCTIVITY, CAMBRIDGE, MA; DR. RICHARD K. LESTER, ASSOCIATE PROFESSOR OF NUCLEAR ENGINEERING, EXECUTIVE DIRECTOR, MASSACHUSETTS INSTITUTE OF TECHNOLOGY COMMISSION ON INDUSTRIAL PRODUCTIVITY, CAMBRIDGE, MA; DR. SUZANNE BERGER, PROFESSOR AND HEAD, DEPARTMENT OF POLITICAL SCIENCE, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MA, ACCOMPANIED BY RICHARD KAZOS, RESEARCHER AND DOCTORAL CANDIDATE; AND DR. ROBERT M. SOLOW, MASSACHUSETTS INSTITUTE OF TECHNOLOGY PROFESSOR OF ECONOMICS, NOBEL LAUREATE IN ECONOMICS, VICE-CHAIRMAN OF MASSACHUSETTS INSTITUTE OF TECHNOLOGY COMMISSION ON INDUSTRIAL PRODUCTIVITY, CAMBRIDGE, MA

Dr. DERTOUZOS. Thank you, Senator, for your welcoming remarks, both personally and on behalf of the MIT Commission on Industrial Productivity.

I am very glad to be here today with my colleagues to present you with the results of the MIT Commission on Industrial Productivity, especially as these results relate to Government. And since our main message is how to bring technology and human resources together toward the new systems of production, we are particularly pleased to testify before this committee, which takes as its principal concern the human resources of this Nation.

Our commission was formed by President Paul Gray of MIT to find out what happened to U.S. industrial performance and what we and others might do, especially in Government, industry and education, to help.

Unlike most other studies that look at this problem from a macroeconomic approach, we decided to take up a bottom-up view. We studied eight industries in detail: automobiles, chemicals, commercial aircraft, consumer electronics, machine tools, semiconductors computers and copiers, steel, and textiles.

We focused on manufacturing because it is critical to this Nation's economic future. As we shall see, our findings apply equally well to the non-manufacturing side of the United States economy.

To carry out our work, we split ourselves into eight groups, and we conducted 550 interviews in three continents, concentrating on what happens at the factory floor, in the office, and in the board room.

We also formed a ninth group on education, headed by Professor Berger who will testify here today, and we studied education from kindergarten to the workplace because of the central and critical role that education plays in this Nation's industrial performance.

The commission then searched for patterns in the results that emerged, and we looked for patterns of weakness and strength as well, Senator. Our book, "Made in America," reports in detail on these weaknesses and strengths. In addition to this book, the MIT Press will present our working papers, which are two volumes of the material that was used as background for this book and was the result of our studies.

I will begin with the six weaknesses in turn These are weaknesses in the U.S. industries that we studied, recurring weaknesses that contribute to weak industrial performance.

First, many, but not all, of our companies pursue outdated strategies. They cling to the rigid mass production system of large runs of identical goods, which was in fashion in the days of Henry Ford, where workers and suppliers are all cogs in a big wheel of production that somehow must be kept turning no matter what. If a worker or a supplier does not perform, they can be replaced just so the wheel of production would keep turning. This system worked well in the past but can no longer compete with the new systems of production, which are different. They are flexible; the workers are involved. Instead of producing large runs, they produce small runs. Instead of identical products, they produce differentiated products, and they cater to the customized needs of the individual consumer.

These practices, which are followed by the best companies worldwide, both here and abroad, are proving to be more productive than the older system. Yet most of our companies cling to that older system.

In addition to that, we tend to be parochial, looking to the U.S. as the sole source of everything and, in particular, of technologies.

Second weakness: short-time horizons. Many United States companies focus on quick profits in the short term They abandon areas of expertise, like consumer electronics, and enter other businesses like rental car agencies, where they believe that their return on investment will be quicker.

As a result of "not sticking to their knitting," as we call this behavior, they lose out to their competitors that concentrate on building expertise and market share ahead of profits.

And so it is that in consumer electronics, where we once dominated the market, we are now down to a bare four percent of what we consume We produce only four percent of what we consume.

Third weakness: technological weaknesses in development and production. The United States is first in the world in inventing new products. The transistor, the color television, the VCR, the fax machine, and the older numerically controlled machine tools were

all invented here. Yet hardly any of these products are made here today, and the products that are made here, like automobiles, have twice as many problems in the first six months of use as the cars made in Japan.

Compared to the world's best companies, we do not build quality into our designs, and we tend to look for breakthrough strategies—we look for the great "Aha"—instead of pursuing the more painful road of steady product improvements.

Fourth weakness discovered by the commission, and very relevant to your committee, is the neglect of human resources. First and foremost—and this, we believe, is the biggest weakness we found—we have neglected and continue to neglect education at the kindergarten through 12th grade level. The United States, the Nation that pioneered mass education, ranks today somewhere between 8th and 15th among the nations of the world in reading, arithmetic, and geography and other such topics.

This slippage is happening at the worst possible time: when the new systems of production call for greater technical literacy, and when the demographic shifts require that we pay special attention to increased participation in the work force of women, blacks, and Spanish-speaking Americans.

Second, beyond neglecting kindergarten through 12th, we neglect our work force. We still view in many of our companies labor as a cost factor to be minimized, rather than a precious asset to be nurtured and cultivated and developed. Our vocational schools are ineffective, and on-the-job training in the United States involves either remedial reading or excessively narrow training, or "following Joe around." The result is that our work force is narrowly specialized, inflexible, and, therefore, less productive compared to the work forces of other nations that receive a broader systematic rotation among jobs.

This neglect of our human resources, as I said, is the biggest weakness that we face, because, as we shall all testify today, it is the effective integration of human resources and technology that is critical to the Nation's industrial performance.

Now, Senator, we looked also at the universities and spent a lot of time studying our own university and the changes we should make there. But we should keep in mind the priorities. Our biggest problem is the K through 12 problem. After that comes the vocational education and the on-the-job training problem, and last, I would say, comes the university issue, because there we are among the best in the world in higher education. That does not mean there is not anything to be done there, but it is just third in our priority list.

Now, because of the significance of the human resource issue, both in school and on the job, to the productivity of the United States companies, my colleagues will focus their testimony on the issues surrounding this weakness today and what we can and must do to address it.

Professor Richard Lester, who will testify after me, will speak on the relationship between the education of human resources and the productive performance of these resources.

Professor Suzanne Berger, who will testify third, will tell us about the way human resources are treated in the United States

and in other countries, and of the consequences of such treatment and the differences that we see between the U.S. and other countries.

Finally, Professor Robert Solow will testify on investment in human resources in the broadest sense of the word.

Now, let me proceed to the fifth weakness: failures of cooperation. We found a lack of cooperation within our companies, where rigid compartments and organizational hierarchies keep, for example, designers and producers from working with one another. The result is delays of as much as two to one in going from concepts to products.

We also found a lack of cooperation among United States firms; for example, between a company and its suppliers, where what binds a company and its supplier is the adversarial contract and the fear of litigation, rather than the pursuit of common goals, as is the case with the best companies worldwide.

Sixth and final weakness: Government and industry at cross purposes. When we began our study, we were told by our business friends that too much Government was the cause of America's productivity plight. Our industry studies did not bear this out, nor the converse.

What we did find out from our studies is that Government and industry seem to be marching under different agendas as if they were oblivious to each other's goals and needs.

Now, beyond the above weaknesses, the MIT commission identified three broad future trends that, in our view, will shape the business environment in the next decade or two.

One, the world, we believe, will become more international, both in the ownership, the location of the work force and so forth. By being more international, it will become effectively smaller, and competition will intensify.

Second, people will expect and will get higher quality, more sophisticated products. Again, this calls for more sophisticated systems of production and a better-educated work force.

Three, technology, particularly information technology and materials technology, will become more critical to the production of goods. This means that our work force must be literate and, in particular, more technologically literate in the future.

Now, the MIT commission also searched for and was happy to find patterns of strength among the Nation's best companies. We looked for companies that were doing as well or better than their foreign adversaries and found several. I will report essentially on what they do as I now summarize what we call our imperatives. But let me explain how we did this.

We combined what we learned from the weaknesses on the one hand, the strengths that we found on the other, and the trends that I listed for the future. We combined these three things to reach our conclusions. Our conclusions are five broad strategic imperatives that, if followed by industry, Government, and the Nation's educational institutions, will help America regain its productive edge. I will list these five imperatives in turn.

One, focus on producing well the new way. What we mean by this is that we must stop putting finance ahead of production, and we must focus as much attention on the processes that take an in-

vention and convert it into a product as we now do on inventing new products.

The Federal Government can help here by extending its support of the United States research and development to the support of innovation in production processes.

Now, Senator, we do not ask that we reduce our support of basic research. We just think we should put more emphasis on research and development on the downstream phases of turning an invention into a product.

The CHAIRMAN. We are mindful that the R&D research program in the tax is supposed to expire this year, too. So if there is not action taken, the cost of that is about $3 billion. That has not even been considered in terms of the budget recommendations that are before us at this time.

I hear what you are saying, both in regard to basic research and the application of research.

Dr. DERTOUZOS. Yes. Let me highlight this further, if I may, Senator. In the United States, we put two-thirds of our industrial R&D funds on the inventive side and only one-third on the downstream side, the processes. Japan has these numbers the other way around. They put two-thirds of their industrial R&D money——

The CHAIRMAN. Is that the structure of the tax credit? Is it the way that it has been structured, or is it just the application of how they utilize the credit?

Dr. DERTOUZOS. I do not know the exact deep reasons for this, but it may be a combination of tax issues and intent.

The CHAIRMAN. Maybe you can let us know as you continue.

Dr. DERTOUZOS. Right. So the first imperative is to focus on producing well the new way, under new systems of production.

The second imperative: cultivate a new economic citizenship. We think, Senator, this is very relevant to your committee. Let me explain.

As we discussed, the old rigid system of production, where workers are cogs in the big wheel of production, works no more. It does not make as much money as the new sophisticated systems of production where workers are more involved. So employees must be given greater breadth and responsibility, and they must be given broader on-the-job training in order to be productive when they use the new sophisticated and flexible systems that I described.

But since so much more is asked of the work force, they should also be rewarded with greater participation in the firm's gains and with greater employment stability.

Now, beyond the utilitarian aspects of getting more productivity out of the work force, we see here an unprecedented opportunity to give the United States work force a new sense of mastery of their work environment and a greater job satisfaction. That is why we call it a new economic citizenship.

Third imperative: blend cooperation and individualism. Now, we can begin doing this through all kinds of new partnerships. In addition, our companies can flatten their organizational hierarchies, which are very deep today, with many layers of management, and we could begin rewarding with bonuses both individualism and cooperation.

The Federal Government in particular should endorse and seek to diffuse labor-management cooperation and worker participation in both union and non-union settings.

Fourth imperative——

The CHAIRMAN. Let me ask just on that point. I have gotten through most of the book actually yesterday afternoon and last night. In commenting or developing that point in the course of the book and looking at other countries, those countries that have powerful trade unions, are they able to get that transition? I mean, if you take the Federal Republic of Germany, there are a lot small numbers but very rigid. In moving back and forth in terms of different trades, have you been able to find in these other areas rigidity of trade union movement? Is it their own internal positions, or is the failure—is it the executive bringing them into the process and letting them try and work it through? How were they able to do that?

Dr. DERTOUZOS. Let us hold this question for Professor Berger, who studied the German system.

The CHAIRMAN Okay.

Dr DERTOUZOS. I think she will give us some interesting comparisons.

Fourth imperative: learn to live in the world economy. To compete in the world, Americans must learn foreign languages, cultures, and practices. The world is becoming smaller, and we must shop internationally for the best technologies, wherever they may arise. We need these for producing wealth.

Now, protectionism is no way to live in the world economy for it invites retaliation. We must insist, however, often fiercely, that American goods be treated as fairly abroad as are foreign goods at home.

Finally, the fifth imperative that we call for is to provide for the future. We must invest, in the broadest sense of the word, in basic education and in technical literacy. This will enable a larger fraction of our citizens to participate in and benefit from more productive working careers. And we must establish national policies that will help us balance the budget and stimulate savings for productive investment.

Finally, we must invest in this Nation's infrastructure, both old and new, including research and development.

Now, these imperatives are for Government, for industry, and for the educational institutions of this Nation.

To conclude, we believe that if Government, industry, and the educational institutions do follow these broad imperatives, then we can, indeed, pull together and regain the productive edge However, this will require a great deal of effort and a considerable change of attitudes on all sides. Yet we believe that it must be done. because if we want to live well, we must produce well. We do not think there are any shortcuts

Thank you, Senator

[The prepared statement of Dr. Dertouzos (with an attachment) follows:]

The MIT Commission on Industrial Productivity was formed two and a half years ago by MIT President Paul Gray to find out what happened to U.S. Industrial Performance, and to establish how MIT and others, including Government, Industry and Educational Institutions , might help.

Unlike most other studies of this problem that generally take a macroeconomic approach, the MIT Commission based its work on a bottom-up study of 8 Industries --Automobiles, Chemicals, Commercial Aircraft, Consumer Electronics, Machine Tools, Semiconductors computers and copiers, Steel, and Textiles.

We focused on manufacturing because it is critical to this nation's economic future. As we shall see, our findings apply equally well to the non-manufacturing side of the U.S economy.

To carry out our work, we split ourselves into eight groups, and conducted 550 interviews in 3 continents, concentrating on what happens at the factory floor, in the office and in the boardroom.

We also formed a ninth group on education -- from kinder-garten to workplace --because of the central role that education plays in this nation's industrialperformance.

The Commission then searched the results that emerged from these groups for common patterns of weakness and strength.

I will begin with the six weaknesses in US industrial performance that emerged from the MIT study:

1.Outdated Strategies

Many U.S. companies still cling to a rigid mass production system of large runs of identical goods. where workers and suppliers are all cogs on the big wheel of production --a wheel that must be kept turning, no matter what.

This system worked well in the past, but can no longer compete with the new flexible systems that produce shorter runs of custom products and have been adopted by the best companies, worldwide.

We also tend to be parochial, looking to the U.S. as the sole source of everything, and in particular of technology.

2. Short time horizons

Many US companies focus on quick profits in the short term. They abandon areas of expertise, like consumer electronics, and enter other businesses like rental car agencies, where they believe that their return on investment will be quicker.

As a result of "not sticking to their knitting", they lose out to their competitors that concentrate on building expertise and market share ahead of profits.

And so it is that in consumer electronics where we once made 90% of what we used, we are now down to 4%.

3. Technological Weaknesses in Development and Production

The US is first in the world in inventing new products: Transistors, Color TVs, VCRs and FAX machines were all invented here.

Yet, hardly any of these products are made here today. And the products that we make, like , automobiles have twice as many reported defects as Japanese cars.

Compared to the world's best companies, we do not build quality into our designs and we look for breakthrough strategies instead of pursuing the more painful road of steady product improvements.

the more painful road of steady product improvements.

4. Neglect of Human Resources

First, and foremost, we have neglected and continue to neglect education at the K-12 level.

The United States, the nation that pioneered mass education, ranks today between 8th and 15th among the nations of the world in reading, arithmetic, and geography.

And this slippage is happening at the wrong time -- when the new systems of production call for greater technical literacy, and when the demographic shifts require that we pay special attention to increased participation in the workforce of women, blacks and Spanish-speaking Americans.

Second, we neglect our work force We view labor as a cost to be minimized, rather than a precious asset to be cultivated. Our Vocational schools are ineffective, and on-the-job training in the US involves either remedial reading, or "following Joe around". The result is that our workforce is narrowly specialized, inflexible, and therefore less productive.

This neglect of our human resources is the biggest weakness that we face, because, as we shall testify today, the effective integration of human resources and technology is critical to the nation's industrial performance.

Because of that, my colleagues will focus their testimony on the issues surrounding this weakness and what we can and must do to address it:

Professor Richard Lester, will testify on the relationship between human resources and productive performance. Professor Suzanne Berger will testify on the way human resources are treated in the U.S. and in

other countries today, and on the consequences of such treatment . Finally, Professor Robert Solow will testify on investment in human resources, in the broadest sense of the word.

5. Failures of Cooperation

We found a lack of cooperation within our companies, where rigid compartments and organizational hierarchies keep, for example, designers and producers from working with one another. The result is delay in going from concepts to products.

We also found a lack of cooperation among U.S. firms -- for example between a company and its suppliers, where what binds them together is the adversarial contract, rather than the pursuit of common goals.

6. Government and Industry at Cross Purposes

When we started our study, we were told by our business friends that too much government was the cause of America's productivity plight

Our industry studies did not bear this out. Nor the converse.

What we did find out from our studies is that government and industry seem to be marching under different agendas, as if they were oblivious to each other's goals and needs.

Beyond the above weaknesses, the MIT Commission has identified 3 broad future trends that , in our view, will shape the business environment in the first part of the 21st century:

1. The world will become more **international**, hence even smaller

2. People will expect and will get higher-quality, more **sophisticated** products.

3. **Technology** --particularly information technology, biotechnology and material technology -- will become more critical to the production of goods.

These trends signal the need for greater agility, flexibility and sophistication by the US productive enterprise if we are to compete effectively in the world.

The MIT Commission also searched for and found patterns of strength among this nation's best companies.

We then combined what we learned from these weaknesses, strengths and future trends to reach our conclusions.

They are five broad imperatives, that if followed by Industry, Government and the nation's Educational Institutions, will help America regain its produotive edge.

1. Focus on Producing well the New Wa:

This means that we must stop putting finance ahead of production, and we must focus as much attention on production processes as we do on inventing new products.

The federal government can help here by extending its support of U.S. R & D. to the support of innovation in production processes.

2. Cultivate a New Economic Citizenship

As we have discussed, the old rigid system, where each individual worker is a tiny and expendable cog on a big wheel works no more.

Employees should be given greater breadth and responsibility and broader on the job training in order to be productive when they use the new sophisticated and flexible systems of production.

And since so much more is asked of the work force, they should be rewarded, both with participation in the firm's gains and with greater employment stability.

We see here an unprecedented opportunity to give the US workforce a new sense of mastery of their work environment, and a greater job satisfaction.

3. Blend Cooperation and Individualism

We can begin doing this through all kinds of new partnerships.

Companies, should flatten their organizational hierarchies and should rewarding with bonuses both individualism and cooperation.

The federal government should endorse and seek to diffuse labor management cooperation and worker participation in both union and non-union settings.

4. Learn to Live in the World Economy

To compete in the world, Americans must learn foreign languages, cultures, and practices And we must shop internationally for the best technologies wherever they may arise.

Protectionism is no way to live in the world economy, for it invites retaliation. We must insist, however, that American goods be treated as fairly abroad as are foreign goods at home.

5. Provide for the Future

We must invest, in the broadest sense of the word, in basic education and in technical literacy. This will enable a larger fraction of our citizens to participate in and benefit from more productive working careers.

And we must establish national policies that will help us balance the budget, and stimulate savings for productive investment.

Finally, we must invest in this nation's infrastructure both old and new, including Resarch and Development.

To conclude, the MIT Commission believes that Government, Industry and the Educational Institutions of the United States can pull together to carry out these interrelated imperatives.

This, however, will require a great deal of effort and a considerable change of attitudes on all sides.

Yet, it must be done!

If we want to live well, we must produce well.

There are no shortcuts!

News Office
Massachusetts
Institute
of Technology

Room 5-111
77 Massachusetts
Avenue

Cambridge
Massachusetts
02139

Telephone
617 253-2700

Contacts Naomi Chase or Ken Campbell, MIT (May) 212 593-6400
on May 3 & after 617 253-2700 or 258-5401
Frank Walton, Ruder-Finn 212 593-6330

MIT COMMISSION ON INDUSTRIAL PRODUCTIVITY PRESENTS STUDY TO SENATE LABOR-HUMAN RESOURCES COMMITTEE

MIT Commissioners Include Nobel Economist Robert Solow

Advance for Release, Wednesday, May 3, 1989

CAMBRIDGE, Mass.--The Massachusetts Institute of Technology Commission on Industrial Productivity took its case for revitalization of American industry and education to Washington today (Wednesday, May 3), giving a Senate committee a series of suggestions for strengthening the federal government's role in creating a more productive nation.

Four members of the Commission, which has reported that the American economy "exhibits a lower level of cooperation among business, government and labor than any of its major competitors," were to speak this afternoon before the Senate Labor and Human Resources Committee, chaired by Senator Edward M. Kennedy (D-Mass.)

All MIT faculty members, they are Commission Chairman Michael L. Dertouzos and Vice-Chairman Robert M. Solow (who won the Nobel Prize in economics in 1987), Professor Richard K. Lester, executive director of the Commission, and Suzanne Berger, head of the MIT Political Science Department.

The hearing will take place at 2:30 p.m. in the Dirksen Senate Office Building, Room 430.

The Commission members, who held a news conference in New York City yesterday to summarize the findings of their two-year study of eight industries from the factory floor up, were focusing in Washington on the impact of government as revealed in the study, *Made in America: Regaining the Productive Edge*, published by the MIT Press.

In discussing potential strategies for the government, the report stresses one of its major conclusions, "that the principal responsibility for improving industrial performance rests with the private sector." In this regard, it notes that "too much direct governmental involvement in the process, at least in the American economy and society, could be counterproductive."

Nevertheless, the report maintains, the government does have an important role in three broad areas: macroeconomic policy, education, and technology policy.

In the first category, it says, the most important task "is to ensure that capital is available to American firms at a reasonable cost, comparable to that borne by the nation's major trading competitors." Among other things, the Commission says, this will require measures to increase private savings and reduce the federal budget deficit.

Summary of Made in America: Regaining the Competitive Edge, by the M.I.T. Commission on Industrial Productivity.

American industry, once the marvel of the world, is not producing as well as it ought to produce, as well as it used to produce, or as well as the industries of other nations have learned to produce, according to Made in America: Regaining the Productive Edge, a major report by the Massachusetts Institute of Technology.

According to MIT, the weaknesses in American industry concern the way people think, cooperate, invest, manage, and organize themselves, as well as the ways they become educated, use technology, learn a new job, and interact with government.

The study calls for a new focus on production--a better blend of technology and human resources--including the necessity of treating the work-force as an asset rather than a cost. "We have to learn how to produce well in the new world climate," according to Michael L. Dertouzos, the primary author. "We already know how to bounce financial instruments from one mirror to another."

"The world has changed irrevocably, and this country, including industry and the entire educational system, hasn't caught up. If the United States is to live well, it must produce well. America does indeed have a serious productivity problem which if left unattended, will impoverish America relative to other nations that have adapted more quickly and effectively to pervasive changes in technology, markets, and attitudes." If we don't correct this problem, "all Americans will pay the price in terms of our living standard," according to Dertouzos.

The report was prepared by the MIT Commission on Industrial Productivity. Sixteen MIT faculty members served on this Commission. The Commission spent two years in a bottom-up study of eight industries: automobiles; chemicals; commercial aircraft; consumer electronics; machine tools; semiconductors; computers and copiers; steel; and textiles. Representatives of the Commission visited more than 200 companies and 150 plant sites and conducted more than 500 interviews in the U.S., Europe, and Japan.

THE PRODUCTIVITY PROBLEM

According to Made in America, the U.S. faces two serious productivity-related problems:

1. A general productivity slowdown and the need to restore the economy-wide growth rate to something approaching the long-term historical average.

2. The erosion of America's long-standing productivity advantage over other nations.

The report points out that manufacturing will be an essential part of the nation's economic future under any circumstances. The important question is not whether the U.S. will have a manufacturing industry, but whether it will compete as a low-wage manufacturer or as a high productivity producer. The report concludes that the most desireable result is to retain on American soil those industries that have high and rapidly rising productivity.

CAUSES OF WEAK PRODUCTIVE PERFORMANCE

Made in America cites six recurring patterns of weakness in productivity performance:

- Outdated Strategies
- Short Time Horizons
- Technological Weakness in Development and Production
- Neglect of Human Resources
- Failures of Cooperation
- Government and Industry at Cross-purposes

Outdated Strategies

Two types of outdated strategies have impeded American industrial progress, 1.) an over-reliance on mass production of standard commodity goods, 2.) an economic and technological parochialism that blinded Americans to the scientific and technological innovations developed in other countries.

Short Time Horizons

Made in America argues that American industry has also been weakened by its use of short time horizons and a growing concentration on short term profits.

Technological Weaknesses in Development and Production

Although the U.S. is still the leader in basic research, U.S. companies increasingly find themselves lagging behind foreign rivals in the commercial exploitation of inventions.

The report charges that U.S. companies find it difficult to design simple, reliable, manufacturable products; fail to pay enough attention at the design stage to the likely quality of the manufactured product; pay insufficient attention to manufacturing processes; and under-exploit the potential of continuous improvement in products and processes.

Neglect of Human Resources

The commission calls for major reforms in the American educational system. Without major changes in the ways schools and firms train workers over the course of a lifetime, no amount of macroeconomic fine-tuning or technological innovation will be able to produce significantly improved economic performance and a rising standard of living.

In the work place, training too often amounts to little more than 'following Joe around.' Firms in other countries are more likely to be seen as learning institutions, where education and training enable employees to develop breadth and flexibility in their skills for the long term.

Failures of Cooperation

Underdeveloped cooperative relationships between individuals and between organizations are major as obstacles to technological innovation and the improvement of industrial performance. Made in America documents a lack of cooperation at several levels. The relationships affected include those between individuals and groups with firms, between firms and their suppliers or their customers; among firms in the same industry, and between firms and government.

Government and Industry at Cross-Purposes

Firms operate in an environment shaped by federal macroeconomic policy and by a variety of other government policies concerning education, training, research and development, national security, economic and social regulation, and the nation's economic infrastructure. It has not been the amount of government intervention--too much or too little--but the kinds of intervention that have hurt productivity. Where problems arose, it was usually from the adversarial and protracted nature of the regulatory process rather than in the strictness of the regulations themselves.

TRENDS: INTERNATIONAL, SOPHISTICATED, TECHNOLOGICAL

The commission identified "three major and pervasive long-term trends with broad implications for the productive performance of tomorrow's firms." Business will become more international, markets more sophisticated, and products and processes more technologically-intensive, the commission said.

FIVE IMPERATIVES FOR A MORE PRODUCTIVE AMERICA

Focus on Producing Well--Put Production Ahead of Finance

The U.S. needs to make a major commitment to technical and organizational excellence in manufacturing after years of relative inattention. Managers will no longer be able to remain detached. Managers who don't know production "will lose the competitive battle to managers who know their business intimately."

Cultivate a New Economic Citizenship--An Involved, Educated, Responsible and Rewarded Work Force

Made in America asserts that education for technological competence is crucial for raising the productivity of American firms. Effective use of new technology will require people to develop their capabilities for planning, judgement, collaboration, and the analysis of complex systems. Learning, especially on the job, must acquire new importance, and the primary responsibility for achieving this goal rests with individual firms, supported by government, labor and educational institutions. The interest, involvement and responsibility of employees should be increased, and greater employment stability and new rewards must be provided.

Promote the Most Productive Blend of Cooperation and Individualism

Organizational hierarchies should be restructured into fewer job categories to promote cooperation, as has been done in some leading American firms. Schools and companies should reward both individual achievement and cooperative team achievement. Cooperative relationships within a firm, and among firms in the same industry, are a necessity. Partnerships among business, labor, government, universities and localities should be encouraged.

Learn to Live in the World Economy

To compete successfully in a world that is becoming more international and more competitive, Americans must also expand their outlook beyond their own boundaries. Americans should understand foreign languages, cultures and practices; shop internationally for technologies and materials, and look for best industrial practices and benchmarks of productive efficiency.

Provide for the Future--Invest in Education, and Save for Productive Investment

Improving elementary and secondary education is probably the single most important challenge facing America today. Americans must be provided with a fundamentally different education from what they receive today. Only a tiny fraction of young Americans are technologically literate and have some knowledge of foreign societies. Unless the nation begins to remedy these inadequacies, it can make no real progress on the rest. The Federal government must provide incentives to local and state govenments to improve primary and secondary education.

Finally, the federal government should stimulate productive investment by reversing the direction of its current fiscal, monetary and tax policies. The report suggests an expansionary monetary policy with tighter fiscal policy; a fiscal policy which taxes consumption more heavily than saving or investment, and a tax policy which encourages private and public saving. Decreasing the federal budget deficit should receive the highest priority.

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The CHAIRMAN. Thank you very much.

I think the way that we will proceed is to hear from the whole panel and then get into the questions, so that we can inter-relate some of these answers. I would ask for Dr. Lester, who is the associate professor of nuclear engineering at MIT, to proceed.

Dr. DERTOUZOS. I would like to say that Professor Lester was the executive director of the commission and head of the staff, Senator.

The CHAIRMAN. He is also internationally known for research on nuclear energy systems and policies.

And Suzanne Berger is head of the Department of Political Science and international professor of political science at MIT. If she could come up. She has been elected to the American Academy of Arts and Sciences. We are glad to have you here.

Then Dr. Solow, I know, is winging his way in here to check some of the modern technology.

Dr. LESTER. Mr. Chairman, thank you for the opportunity to appear here today to discuss some of the human resource aspects of American industrial performance. My testimony today, like that of my colleagues, is based on the work of the MIT Commission on Industrial Productivity.

My task is to discuss the relationship between education and training on the one hand and industrial productivity, or productive performance, broadly defined, on the other. But before I do so, I want to make a few points about recent trends in U.S. industrial performance.

First of all, despite a number of positive recent developments, there remain disturbing negatives, the most important of which is that the U.S. continues to have a serious productivity problem that is now almost two decades old. Productivity growth in terms of real output per hour has been limping along at not much more than one percent per year. In the long run, there is a direct relationship between productivity growth and trends in the standard of living, and the weak productivity growth that we have experienced has had a great deal to do with the fact that real hourly wages have risen only very slowly over the last decade—and, indeed, by some measures, have not risen at all.

Unless we improve our productivity performance, we face the real and disturbing prospect that our children's standard of living will not be significantly higher than our own, and perhaps not even as high.

Secondly, as Professor Dertouzos mentioned, the commission identified what it has described as a pervasive neglect of human resources as one of the most important contributors to our weak productivity performance. This begins in the Nation's primary and secondary schools, extends to vocational education, and on through retraining and training in the workplace. Within the workplace, our book refers to a systematic undervaluation of how much difference it can make when people are well educated and when their skills are challenged.

In the past, these weaknesses were less important to our competitive position. We could afford weaknesses here because we had strengths in so many other areas. But three factors—competition from overseas, technology, and demographics—are making these weaknesses progressively more serious.

First of all, more and more countries are becoming capable of producing and exporting sophisticated goods and services, in significant part because they have understood the value of and, in some cases, improved on the system of universal education that was pioneered in this country.

What this means is that in many cases, in many areas, U.S. firms will not be able to compete on the basis of cost alone, and the future of American industry will increasingly lie in specialized high quality products targeted at increasingly sophisticated and demanding markets—which leads to the second point: That the systems of production that are required to do this will place ever greater demands on the work force. Broader skills, greater technical literacy, greater responsibility—all of these will be needed if we are to exploit the new technology to the full extent.

In the days when mass production held sway, automation could substitute for human skill and intelligence. But the new automation is a very different kettle of fish.

Third, at the same time that these two developments are occurring, the majority of new entrants into the labor force during the coming decades will be drawn from groups—blacks, Spanish-speaking people, immigrants, women—that the education system has not served as well.

I want to turn now, if I may, to the relationship between education and industrial performance. Here, rather than talking about average SAT scores or average years of education and the effects of these things on aggregate productivity levels, I want to mention some cases that address what is happening inside those two black boxes, if you like, and show how education and training can lead to real improvements in industrial performance at the firm level. Let me try to do this with four very quick examples drawn from our own and other studies.

First of all, several different researchers have recently pointed out that the American manufacturing industry has been quite a lot slower than their Japanese rivals, as well as others, to adopt advanced manufacturing technology. Now, there are a number of reasons for this, but an important one, it is clear, is a lack of user sophistication about these technologies, both among managers and also on the shop floor.

German machine tool builders over and over again told us during our study that they thought that the lower skill levels of the American production worker are one of the main reasons for there being limits on the rate of introduction of this new technology. One of them said that his company gives five inches of documentation to American firms that buy his systems for every one inch given to German firms. In other words, American workers tend to require much more detailed instructions than their German counterparts when it comes to using these machines.

Another researcher compared the use of the same computerized flexible manufacturing systems in the U S and Japan. He found that the Japanese were far better able to exploit the full potential for flexibility of these new machines. They produced ten times the number of parts and introduced 22 new parts for every one new part produced by American companies.

Once again, a major reason for this, in the view of this——

The CHAIRMAN. Could I ask this? Also in your book you point out that in some industries American productivity is even ahead of the Japanese in some limited areas.

Dr. LESTER. Yes.

The CHAIRMAN. You will develop that?

Dr. LESTER. I think that I will come, in fact, to examples.

The CHAIRMAN. Okay. Just steer us so we know why it is that way in that one case, and then the examples you have used in the book that come back the other way and how you draw the distinction.

Dr. LESTER. Yes, indeed.

The CHAIRMAN. Thank you.

Dr. LESTER. We will come to that.

To finish this example, however, I want to make the point that once again it appears to be differences in the skill levels and technical literacy of the two work forces that has a good deal to do with these differences in usage patterns. The Japanese workers were better trained, better able to solve problems as they arose on the shop floor, and were encouraged by their managers to experiment with the machines to improve their performance.

In contrast, in the American plants that were studied in this comparative work, there was a philosophy of, as was mentioned: "If it ain't broke, don't fix it." And workers were discouraged from making changes to the system once it was up and running.

If I may just add one third example, we compared during the course of our study technical problem-solving practices at integrated steel plants in the U.S. and Japan and saw a similar thing. At the American plants, the production workers and their supervisors typically had only rudimentary training and often did not know enough about the technical details to solve problems on their own. If the problem was small, it might be ignored, and only if it were serious would something be done. And what was usually done was to call in a trouble-shooting team which was based somewhere else, a trouble-shooting team with better technical knowledge. There would often be a delay, sometimes of several weeks, before the problem could be attended to.

In contrast, in the Japanese plants that were looked at, again, in this comparative study, the necessary technical expertise was continuously there at the plant. And instead of functioning in a fire-fighting capacity, these in-plant groups were continually looking for ways to improve the process. They said that in their view the best way to prevent serious problems from developing was to pay prompt attention to the small and routine ones.

Now, to the question that you raised. What was interesting was that some of the best U.S. examples, the best examples that we found in U.S. companies of how innovative human resource policies can promote good performance also came from the steel industry; in this case, the mini-mill sector of the industry. One mini-mill company achieved tremendous improvements in productivity by being willing to treat its plant almost like an R&D laboratory. Its goal was, and is, to be the lowest cost producer of its kind of steel in the world, and at the time we visited the plant, indeed, it was.

Everyone involved in that plant, from production workers all the way up to the management, is encouraged to keep their eyes open

for ways to make the process run better. The company makes a great point of scouring the world for new ideas. It sends teams overseas, including production workers and maintenance workers, who often will see things that engineers and managers may not see in these overseas plants, and even provides what it calls industrial sabbaticals for everyone in the company to do this.

Another thing that it does is to make production workers responsible for meeting with the customers. They learn what the customers want; the customers learn what they can do; and everyone benefits from this interaction. It is an example of a phenomenon that we are beginning to see in the best American companies of breaking down traditional organizational barriers and hierarchies, giving increased responsibility, broader job definitions to people on the factory floor.

The conclusions, if I may draw a couple from these kinds of examples, more of which appear in our book, is that, first of all, there is a direct effect. Better trained workers will, in general, produce more efficiently and at higher quality. But there is also an indirect effect which may even be more important. Broader skills, better skills will permit the new forms of organization in the workplace that are needed to achieve more responsive and flexible production systems of the type that Professor Dertouzos was describing.

What are these new skill requirements? First, basic literacy. As responsibility for quality and productivity are pushed further down the hierarchy and closer to the point of production and distribution, production workers will have to be able to read more complicated memos and manuals and also keep better records of their own. They will also have to understand the production process as a whole and not just their own narrow specific tasks.

Second, proficiency in math. As statistical process controls and other quality control techniques spread through American firms, the basic math proficiency of the typical production workers is in many cases proving inadequate.

Third, computer literacy. As computers and microelectronics diffuse through the firm, familiarity with them and with basic programming skills will have to increase.

Fourth, team work. As jobs become broader and teams become more widespread, oral and written communication skills and the ability to work collaboratively will become important, more important.

And, fifth, attitudinal and behavior skills Increasingly, workers at all levels will have to identify the success of their firm with their own involvement in it, with their own reliability, and with their receptivity to learning new skills.

Now, there is a basic question here about the roles that should be played by the firms themselves in developing these skills, not only with respect to job training but also with respect to K through 12 and vocational education.

In some of the leading firms that we visited, education and training are becoming directly linked to corporate strategy. IBM is one company that has embraced this linkage. Ford and Xerox are other companies that are emulating their Japanese competitors and becoming involved not only in their own training programs, but in

the training programs of their suppliers. And a growing number of firms are becoming involved with their local school boards.

But how much can we expect of firms? How much should we expect of firms? Probably more than we have yet seen, but clearly, as you pointed out in your initial remarks, there is a very big role for Government. And we think that there are some basic choices for the country here, and Professor Berger will elaborate on them.

But I want to finish with one last point. There is sometimes a question—and we encountered it during the course of our work—do we really need manufacturing? Perhaps we can let it go and rely on research, our skills, and developing new knowledge, and in the services area. The commission's view of this question is very simple. There is no choice. We must and will have a manufacturing sector. The only choice before us is whether it will be a low productivity and, hence, low wage sector, or a high productivity and high wage sector.

The choice here really does have to do fundamentally with our education and training system. Unless we are willing to greatly strengthen it, no amount of macroeconomic fine-tuning or creativity in the laboratory will suffice to maintain a healthy improvement in our standard of living.

Thank you.

The CHAIRMAN. Very good

Dr. Berger?

Dr. BERGER. Before I begin, Mr Chairman, I would like to introduce Richard Kazos, who is a researcher and doctoral candidate at MIT, who did research on vocational education and community colleges for our study.

The CHAIRMAN. We welcome you here

Dr. BERGER. Our report, as my colleagues have told you, has identified six patterns of weaknesses, five imperatives for industry, labor, Government and schools. But in this very complex picture, I think all of us believe that there is no weakness that is more critical for us than those that we have discovered in the education of Americans for work.

And I would like to make this point first by describing to you very rapidly the differences between the way we educate men and women for work and the ways our principal economic competitors in the world educate people for work; secondly, by telling you what difference these differences make for the economy; and, third, by suggesting some of the things that we think we ought to be doing in order to remedy these weaknesses.

I will start with the first, the difference. I guess the first point one would want to make is that the tracks between kindergarten and the 12th grade run along pretty much the same lines in all major industrial societies. Everywhere we find pretty much the same curricula and the same patterns of schooling. But even in the early years in American primary schooling, we already see a pattern of weakness that is reflected in those achievement tests, some of the results of which you cited at the very beginning of this hearing. We see poorer results of American children from the very earliest grades, and these results become poorer and poorer as these children progress through the school system

We do turn out some exceptional students We do have some outstanding schools. But what is striking in our research is our mediocre the average is, and what stands in real contrast to the performance of our economic competitors is the way that they have succeeded in producing high average competence, high average levels of achievement in their populations. This is one of the truly superior accomplishments of the Japanese school system, for example—not the way in which it produces geniuses, but the way in which it moves the entire population up to a high average level of accomplishment in math, reading and science.

Average performances in the United States are mediocre, and our record for the disadvantaged, for minorities, is dismal. We recently heard a story that I would like to repeat here about a job training and partnership program in Wichita Falls, Nebraska, that aimed at trying to bring more minorities into a track that could lead to engineering education in college.

This was a program that was placed in the 11th grade. By the 11th grade in Wichita Falls, Nebraska, there remained in the school system no income-eligible black males to take this course. So it is clear that the programs that we have start too late. If we are to succeed with some of these pre-engineering programs, some of these programs to move a larger segment of our disadvantaged to youth into the schools, we will need to do much more in the much earlier stages of the game. Eleventh grade is simply too late. We have already lost the game for many of the young people.

The second point that one would want to make is that beyond primary and secondary schools, countries to differ in fundamental ways in the ways in which they track young people into work.

The CHAIRMAN. Just before you move along, you were talking about the trends which you saw in the education system and mentioned this one here. Do you want to elaborate on the other kinds of areas that you were able to observe, other trends as well?

Dr. BERGER. Other trends in K to 12.

The CHAIRMAN. Yes.

Dr. BERGER In K to 12, what we find is, over the three post-war decades, a pattern, a not entirely uniform pattern of decline, but a pattern in which we certainly have not been making gains for the population on average; a pattern in which, on balance, the trend is downward in the achievement scores of young Americans.

Now, there are certain periods in which it seems as if things are turning up a bit. At the end of the 1950's with a lot of attention to science and math, there was a period and a time in which there was a national political leadership that pointed the way to larger expenditures and a larger attention to these issues We did see a period of upturn, but we have now been felled again by periods of downturn in these trends

Well, beyond primary and secondary schooling, what we see are two patterns. We see one set of countries—the United States and Sweden are the best examples of here—one set of countries that use schools for training. And whether we are talking about community colleges or vocational education in high schools or universities, we are talking about a pattern in which most training, most formal training takes place in schools Even when companies want to do training in our country and in Sweden, what they mainly do is rely

on contracting with outside educational institutions for their courses.

A second set of countries—and here we find our main economic competitors, West Germany, Japan—rely mainly on training within companies to prepare young people for work

Now, in the United States, we too have training within companies. But when we looked at what kind of training is provided within companies in our country, we found that this is predominantly of a kind of informal, "follow Joe around on the job" variety, where workers, at best, learn a rather narrow set of skills that enable them to satisfy particular work assignments. Even in some of the best companies, where they do have formal training programs within the company or contract out with schools to provide training, we find that much of this training is extremely narrow and prepare people for only a particular work assignment beyond the training.

Now, in contrast, in West Germany and Japan, when companies train, what they aim at doing is developing workers with a much broader set of general capabilities, with a variety of skills that are not specific to one work assignment, with a variety of skills that can be used in a number of different positions in the same company. How do they do it? They do it in different ways in West Germany and Japan, but the essence of the solutions is to give the person a broad, general understanding of the company, of the industry, of the ways in which the whole system fits together in the company, and not simply a narrow fix on a narrow skills.

Some of the ways that this is done, in West Germany it relies on apprenticeships, apprenticeships that are planned out between Government, union, and industry officials, with curricula that are constantly being reassessed and brought up to date. In Japan, the main solutions are rotating workers around through the plant through a wide variety of jobs, so they get a picture of the whole company. They get a sense of the whole operation. This is what makes the Japanese worker more flexible.

We have noticed that often when people are trying to learn from the Japanese, they fix on one aspect, one quick fix, one gimmick that is in some sense imported from the Japanese, from the Japanese story—quality circles or something like that. In fact, in our own research in Japan, what we came to realize is that what has really mattered here is a pattern of investing in a worker in a way that enhances that worker's capabilities for his or her total work life. This involves an investment that at any one moment does not have a very calculable return. It is not really possible for the West German or the Japanese manager to understand exactly how the forms of training in which they are investing are likely to pay off in the long term. There is a certain act of faith in investing in a worker's career in these forms of broad, general training.

Here, I guess I would like to mention one point that has been brought up quite often to us in our research on training in firms. People have often said the reason that American companies are unwilling to invest in these forms of broad, general training is that the American work force is highly mobile If you invest in a worker, chances are she may be found in some other community ten years from now or five years from now. If you invest in a

worker, it is likely that a competitor may pluck off this worker. So the explanation has been that American companies do not invest in workers, in worker training because it is in some sense not rational or profitable to do so.

We feel this is probably a weak explanation. When we look at West German companies which invest heavily in apprenticeships and realize that the majority of apprentices trained by a West German company go on to work in other companies, and, hence, do not directly contribute to a firm's profitability, we realize that there is a different ethos at work there. And it is an ethos that was expressed to us by one of the West German employers that we interviewed, who said, "We simply have to make investments in the total reservoir of skilled labor in this country. That is where our future as a company lies. And so we lose some, we gain some, but in the long haul, we know that this is what we have to do to survive in the international economy."

That is the kind of ethos that too often is missing in the firms that we looked at in the United States, where very often the spirit is one that was expressed to me by a U.S. textile manufacturer who said, "You know, we really do not have any problems about our workers' skills. Our workers are guys down from the hills who grew up repairing their cars. And those skills are simply adequate."

So the difference in perception of what is needed for a worker in the modern economy is too often a different perception in our country and in those of our principal competitors.

The second point I would like to discuss is what difference it makes for the economy if you do train workers with these broad, general skills. Here we found three broad sets of differences. One are those that Richard Lester has already described in telling you that if you want to use the new technologies, you need to have a work force with broader skills, with a deeper sense of responsibility for the operation, and with a greater flexibility in moving from production, to repair, to a new set of assignments. Those are points that I think Richard Lester has already made.

The second point that I would like to make, though, is that when you have trained workers with these broad skills, you have a set of people who are able to be retrained more rapidly. Since we face times of considerable economic turbulence, periods of reindustrialization and fundamental changes in jobs, we need to have a set of workers who can move on from one set of work assignments to another set of work assignments.

Today in the United States, when skills and jobs become obsolescent, the way that American employers often deal with this is getting rid of the old workers and hiring a set of new folks who have the new skills that are needed. In contrast, in Japan and West Germany, where workers can be rather easily retrained because of the continuous elements of training and rotation in their whole work life, we find that workers are, in fact, much more readily re-employable and reassignable in periods of rapid economic restructuring.

One example that I would give you is the example of what happened to steel workers in Japan. When Nissan Steel had to close down many of its production facilities, it was able to take steel pro-

duction workers and move them into some new Nissan companies that were computer companies and use these production workers as computer programmers, because already as steel production workers they had had extensive experience with computers.

In the United States, in contrast, we have too many experiences of closed plants and workers who remain more or less permanently unemployable, and in which retraining is a terrifying experience for people who for many years have really had no real experiences of learning and who simply no longer have a mindset that is open for learning on the job.

I guess the third set of differences that I would point to between workers who have broad training and workers who have the kind of narrow skills that our schools and plants too often provide, is that when workers have broader training, they usually come to feel a larger sense of responsibility for the company as a whole. And it is easier to involve such workers in planning and in the process of organization of work. There are more cases of collaboration in West Germany and in Japan between employers and employees than are typical in the United States.

Here, I guess I would come back to the question that you raised with Michael Dertouzos. What of the West German unions? It is true that in West Germany there are far more rigidities about job security than there are in the United States. And the way in which the West Germans have remained competitive—in many cases more competitive than we are—with highly rigid employment practices, with many more constraints that we have on hiring and firing, is by training the work force that can be readily re-employed within the same industry at a different set of work assignments. All of this is negotiated with unions, and the training curricula are also negotiated with unions.

So we have found no basic incompatibility between a job situation that provides considerable security and stability of employment for workers and considerable flexibility for companies in moving from one set of productive activities to another. These can be reconciled.

The CHAIRMAN. Is that a result of a smaller number of unions?

Dr. BERGER. No. The West German labor force is much more highly unionized than the American work force.

The CHAIRMAN. It is, but there are fewer unions.

Dr. BERGER. They are fewer in number. There are fewer unions.

The CHAIRMAN. If you have the different ones doing different functions, you have smaller numbers in our country, whether you are going to be able to move through various trades or not, whether you are going to have some dislocation or not. I do not know whether that would make more of a difference or if it would not.

Dr. BERGER. In some of the union contracts in the United States—and this is not a subject on which I am an expert—there has been a willingness to try to negotiate a greater flexibility in movement within the plant in exchange for higher job security. It seems to us that that is the lines along which the solution really should be encouraged, to provide security in exchange for far more flexibility

But the price of that flexibility has got to be a different kind of training, because you cannot move people around unless they genu-

inely have the capability to learn a rather different set of productive activities.

We see in some of these examples abroad opportunities, reasons for us to be concerned about our performance, certain lessons that we can learn, without necessarily ever hoping or wishing to turn ourselves into West Germans or Japanese. We also see a very important role for Government.

I guess first and most important of all, we believe that in order to change the picture in kindergarten through 12th grade, above all there is a need for a fundamentally different approach to education in this country There are many parts to this solution. Some people emphasize the need for greater technological literacy. Other people have talked about longer school years. There are many things we might do.

I guess the one point on which we all agree is that in a situation in which nobody likes paying new taxes but everybody knows in their heart of hearts that we can go nowhere as a society unless we remedy the outstanding weaknesses of the American educational system, there is a real need for political leadership, for people to stand up and say, whatever the cost, we can achieve none of the rest of what we wish to achieve in the economy without a larger commitment, and a commitment of funds as well.

Money is not everything, but when you think that Japanese school teachers get paid what engineers get paid, what that means about that society's values. When you think about the salaries of American school teachers, you realize the signals that we are sending out about the value of education in our society. So one part of the solution has to be a different kind of respect and attention and allocation of resources for these activities. There are other points as well, and here we signal the problem without thinking that we are experts on solving it.

The second set of solutions in problems areas that have to be addressed do involve training. Here we see the need to develop more incentives, both through the tax system and through programs like the Job Training Partnership Act for employers, to develop the kind of training programs that would develop broad competences and not simply narrow, job-specific skills. We need to stimulate firms to give workers a knowledge not only of the narrow job assignment, but of how all parts of the firm put together, of all aspects of industry.

In this sense, we really need a new idea of what vocational education ought to be, and in order to make firms able to pick up on some of these ideas, we do need to find ways of helping small and medium firms who cannot finance through their own resources. We need to be able to stimulate consortiums and other forms of industry association that would enable these small and medium firms together to provide job training solutions to their employees.

Now, whatever good we may think about the in-plant training, company level training—and certainly in Japan and Germany its successes have been outstanding—we do see ourselves as a society that is going to continue to rely on schools far more than other societies in providing skills. And so much of the set of solutions are going to involve new ways of doing things in school.

With respect to traditional four-year colleges and universities, we do believe that they remain very strong. They are the envy of the rest of the world. And when I did my interviewing and studying in Japan of their in-plant training, I was impressed by the extent to which our universities still remain a model for them.

We have also been impressed with the growth in role of community colleges and the way they bridge the gap between formal schooling and the workplace. And these institutions do seem to us something that we need to support and support more broadly.

We were troubled, and we remain troubled, by the experiences with vocational education in our country. We see vocational education in high school as not having a very strong record of building broad-based competence in students, of allowing students to develop skills that will enable them to build lifelong careers. Too often, vocational education continues to provide narrow training that is detached from real job opportunities and real careers. Here, there really could be major improvements if we introduce more opportunities for apprenticeships, for co-op type experiences into that curriculum, if we introduced more broad-based experience in industry as a whole. Here, some of the examples that we have pointed to from the West German experience might be used.

Much needs to be done. We are not experts on all the details here, but we hope that we have at least suggested some of our thoughts on direction.

The CHAIRMAN. Before getting into general questions, could I ask you to elaborate about community colleges and the vocational training programs that you might see?

Dr. BERGER. Could I ask Richard Kazos to respond?

The CHAIRMAN. Sure. Just while he is coming up, you mentioned that the United States and Sweden are more school-based in terms of training. Of course, Sweden has had a remarkable success in training and retraining.

Dr. BERGER. That is right. The Swedes have been remarkably successful with using schools for retraining. So I think there is a store of valuable experience there. It is not that schools cannot do retraining. It is that our schools have not been very good at retraining.

The CHAIRMAN. Good. Okay.

Mr. KAZOS. What I would say we found about community colleges in particular is that they are growing fast, they are flexible, they are responsive to the local labor market in a way that four-year institutions cannot be and in a way that high schools, for the politics of vocational education, usually are not. And we have seen actually specifically in the area of manufacturing, specifically in the Midwest and in the Southeast, great strides being made by community colleges at the State level and consortia of community colleges working on developing advanced manufacturing technical training at the community college level. It seems to be a place where firms and the educational institutions can work together very flexibly towards training that kind of—that technician level that in Germany is done through the apprenticeships and in the U.S. seems to just fall out

The CHAIRMAN. Do they do it through existing programs, or do they do it in spite of the vocational ed programs in the South where you have seen them?

Mr. KAZOS. Well, generally, the programs that I am thinking of in South Carolina and North Carolina are State-funded programs, and also, you know, funded by the firms as well, depending on how specific the training is for the firm.

The CHAIRMAN. Okay. I think we will probably come back to that in the other general questions. In any event, it is interesting, but it is interesting because we have the reauthorization of the JTPA this year; we also have the reauthorization of the vocational education programs this year. And we continue, obviously, in the other education programs to try to find ways where we can breathe some life into some of the ones that are existing, perhaps along some of the ways that you have mentioned. So we will look forward to getting into even further detail about some of those issues.

Let me, if I could, come back just to some general questions, and then move on to some of the other specifics as we wait for Professor Solow.

Could you tell us, Dr. Dertouzos, what is special, really, about this program or this book? There have been enormously valuable and useful studies in all of these areas, but what do you feel is really the most important over-arching thing? And why is this report so special?

Dr. DERTOUZOS. I think you are asking me what is new here and what is big. Permit me to give you an analogy. As you listen to the weaknesses that we reported here, they sound very familiar. The reason they do is because so much has been written in the public press and so many weaknesses of industrial performance have been listed that we have a myriad of these causes. So it is impossible for anyone to identify a weakness without repeating what has been published.

The analogy I want to give you is that if I were sick and somebody walked in the room and said, "You look yellow; you must have liver problems," and somebody else walks in and he says, "You are breathing hard; you must have lung problems." Another one walks in and he says, "You have a common cold," and this goes on and on. Finally, I have a list of a thousand possible diseases, and I know I do not have a thousand diseases. Then a doctor walks in and examines me—I would like to think MIT is the doctor—takes the blood pressure, spends two-and-a-half years studying the patient, and then says, "You have got only two problems." Then do I turn around and say to the doctor, "Go away. There is nothing new here. I heard about these two among the thousand"? Of course not.

We are in the same bind, Mr. Chairman. We have identified six weaknesses, and the most important thing about our report or our book is that out of the myriad of weaknesses, the field that tests what we saw in this bottom-up study of eight industries came up with these six patterns. No more. The other thing is that they are very heavily intertwined and inter-related.

The CHAIRMAN. That brings me to the other question. That is, because they are inter-related and intertwined, how can we best deal with them? We may be just going back at it the same old way, re-

authorizing JTPA and tinkering with that, and reauthorizing vocational education and tinkering with that. I mean, what should we be thinking about in terms of inter-relating or thinking about these questions in a new way?

Dr. DERTOUZOS. Mr. Chairman, you asked us about American companies that are doing well, and we mentioned several. We were surprised by something when we looked at these American companies. They seemed to be following most of our imperatives that are on this chart, the five imperatives. Most.

Now, we were surprised that other companies, the ones that are not doing well, were not making the change, and we tried to understand why. The reason is precisely what you alluded to. They are very intertwined.

Let me demonstrate this. If you look at that chart, we have five imperatives, and the first one is to produce well the new way. Now, the other four imperatives relate very, very tightly to that first one.

For example, we say develop a new economic citizenship, meaning an educated, responsible and rewarded work force. That is clearly needed, as Professor Berger and Professor Lester testified, to make our human resources produce better. Look at the third one. We say promote cooperation and individualism, blend them together. Again, time and again we found that the cooperative work produces shorter delays and better production.

The next one says learn to live in the world economy. Again, our examples in our study show that if we buy the best technologies from all over the world, we do best. So they help, too, producing best. Finally, providing for the future and investing in education. We heard from our colleagues here how this links to productivity.

So these are terribly intertwined. If you see our charts, you see arrows going from each one to the other. And because the companies cannot make all these changes at once, that is why they find it difficult to copy the best practice companies.

Now, you asked what we can do. This is a very tall order. We are no magicians. Government has to play its role; industry has to play its role; and we at the higher educational institutions and the K through 12 institutions have to play their role. We must all pull together, and these translate to various actions for the individual players.

In our book, we list about nine of these actions for Government, and we have other actions for industry and so forth. Again, I want to say that we are not experts in the specific legislation or in giving you details. We can give you only strategic broad brushes.

The CHAIRMAN. You mentioned again the issues of productivity. Dr. Lester mentioned them as well, and the diminution in terms of productivity from the post-war period of three percent to now some, what, one percent?

Dr. DERTOUZOS. That is right.

The CHAIRMAN. Obviously, if companies were following these plans, they would be increasing the productivity You also mention in the book that the motivation by the workers seems to be there in your chapter on that issue.

How much is it up to those individuals? I suppose what I am getting to is the motivation, the change in motivation or is it these

other aspects of, you know, the better training, the higher technical literacy, or the companies following these patterns here? Is there anything that you can tell us about?

Dr. DERTOUZOS. Are you asking me?

The CHAIRMAN. Yes, you and then Dr. Lester.

Dr. DERTOUZOS. Fine. There are two points I think you raise. The first one I want to comment on is the productivity.

Mr. Chairman, it is not only the numerical measure where, you are right, we are down to one percent. There are other aspects which we do not measure: the quality of our products, the time to market and so on. So we define this new term we call productive performance. Indeed, if companies follow these imperatives, we believe that they will increase their productive performance, as have our best practice companies that we have seen. That is the first point.

The second one on motivation I think is very important. We were told at times that the reason we are in trouble in U.S. industrial performance is because of a loss of the passion for work, because we are slovenly, because the ethic of work has gone away. We did not find this to be the case. In fact, if you look at the Numi plant, the Toyota-General Motors cooperative activity, those workers have done as well as the Japanese workers in terms of defects, number of defects in the cars, time to market and so forth. So that it is not the case that American workers have lost their ability to work or their motivation. The motivation is there. What we need to do is to provide the necessary means for utilizing and exploiting that motivation.

The CHAIRMAN. Dr. Lester?

Dr. LESTER. Yes. I can only agree with what has been said. I would add one point about the productivity performance. I think it does bear noting that some of the most impressive productivity statistics in American industry have been racked up by the manufacturing sector, the part that we looked at most intensively. There are a number of reasons for that, but surely one of them has to do with the fact that manufacturing, to a greater degree than other sectors of the economy, has been facing obviously very intense international competition

There is nothing like that competitive force to encourage the kinds of across-the-board changes, in many case wrenching changes, that we suggest have to take place. At the same time, it is also worth pointing out that there are many other areas of the economy, large sections of the economy, particularly in the services area, that have had much more disappointing productivity performance. And if we are really going to achieve significant improvements across the board, we will have to pay close attention to what is going on in the services sector.

The CHAIRMAN. I will ask both of you again this question. We are getting to closer to you, Dr. Berger. Clearly, we have to have a higher priority on math and science, foreign language--you mentioned that. Is there a question about how we encourage it? Also one of the responsibilities we have is oversight of the National Science Foundation and reviewing their focus and attention on the development of these kinds of activities.

Do you have any recommendations or suggestions about what we might do in this area?

We want to note the presence of Senator Jeffords. We have had a fascinating presentation here, Senator, and I know the Senator is very interested in this. I hope you will chime in at any time. We want to keep this informal. We welcome any questions you have.

Just on math, science, how we are going to encourage it? Have you drawn any conclusions about what the NSF is doing in this area that we could help encourage them to do more of?

Dr. LESTER. I want to address one part of that question, if I may. It has been pointed out today that we collectively seem to have had more difficulty in moving products out of the laboratory into the marketplace than some of our competitors overseas. If you ask why that is, it does not seem to be because we are short on creativity in the lab. It does not seem to be that we are lagging in basic research—although obviously it is important to maintain our strength in those areas.

What does seem to be the problem, to a greater degree, is these downstream engineering skills that we have talked about—product and process development, manufacturing skills—which we have in the engineering schools over the last two or three decades allowed to drop to a somewhat lower level in the curriculum, in some cases disappear from the curriculum for a variety of reasons.

We have to increase the attention in the engineering schools as well as in the companies to these kinds of skills. We cannot any longer take the view, as we have done to some extent in the universities, that what we are about in the engineering schools—we invent things. Someone else develops them, and somebody else produces them. But what we really do is invent them.

That will not work any more, so we have to, both in our teaching and in our research programs—and here is where the NSF role comes in—pay much more attention to these downstream functions. I think we all conclude in our report that more Government support in that area without, of course, encroaching on commercial or near-commercial activities, more Government support to generic product development, process development, manufacturing research is a very important thing for the NSF to be doing.

Dr. DERTOUZOS. On that, Mr. Chairman, you are asking about the deficiency, I think, of the scientific and technical people at various levels of our educational system

The CHAIRMAN. How we upgrade that.

Dr. DERTOUZOS. Right. As long as the youth of this Nation think that they can grow up and get rich quick by bouncing a few financial tricks off the mirrors of Wall Street, we are not going to get a great respect for technical literacy.

We think that all the players have contributed to this. The Government certainly has to exhibit leadership and call attention to the Nation about this being a serious issue. We think programs can be established to help teachers and students of science and technology become better. I think there is a bill now being discussed to help give scholarships to science students Industry has to value manufacturing, technology and engineers and pay higher salaries.

If I may I would like to add a personal suggestion, which is not a commission suggestion. I want to make sure it is personal. We com-

plain that 50 percent of our graduate students in these areas of science and technology are foreign, and we call this a problem. And since I am an immigrant myself, I would like to make a suggestion. Perhaps we can set up some legislation that enables any student of science and technology who is foreign to become a U.S. citizen, if not automatically, very easily. That might convert a bug into a feature, as we say in computing.

The CHAIRMAN. Well, as the chairman of the Immigration Committee, I will keep that in mind.

We also have some questions on "brain drain" and some of these other issues where we have responsibility. Let me ask you, we have seen the dramatic change in national policy with regard to support for academic research facilities. If we were where we were even ten years ago and that had been maintained at the current services, it would be up to $2 billion a year. It is virtually zero now. We have seen some authorizations last year, the funding for those programs. We even see some expansion of that function in the budget which would permit, were you able to make the case to the Appropriations Committee. I am afraid the House is involved in some other kinds of interest in this area, which hopefully will be resolved very quickly.

How important is that? Did you look at this? You and then Professor Lester might make a comment, too.

Dr. DERTOUZOS. Yes. We talk about this in our book.

We have concluded that the facilities are, indeed, deteriorating, and we need to pay a lot of attention to this. And we call for attention to facilities as a broader investment in the book.

Let me highlight here, however, something which I think may be new to this committee. The need to get better and higher quality equipment across our laboratories for basic research is paramount. But I want to highlight again the need for steering R&D also in the downstream direction, after the invention stage. This is, Mr. Chairman, where this Nation is weak. We are the greatest inventors in the world. Where we are weak is in converting inventions to product. That takes innovation, and we are not spending enough on that innovation.

So let me remind you again that this, which I think is something new for this committee, should be highlighted.

Senator JEFFORDS. Mr. Chairman, may I interrupt on that point?

On that last issue, there is some criticism that most of the people who are interested and qualified to go into that transition from the discovery stage into what might be commercial, get off into the defense industry because of higher salaries and incentives in that industry. Is that a factor? And if so, how serious of one?

Dr. DERTOUZOS. We looked at the effect of the defense on the commercial sector, and we agree on several issues. First, that it is not as efficient as it could be and could be made more efficient, which is the finding of the Packard Commission. Second, because of the loss of our strategic technologies, like consumer electronics, the fallout coming out of defense is no longer as effectively falling on the commercial sector.

There are people, indeed, who are being attracted by the salaries and the opportunities in the military, but we did not see this as a devastating or major factor in our analysis

Dr. LESTER. Can I just come back to this question of funding for laboratory equipment and facilities. This is a point that was mentioned in our report, and it is obviously a subject that is dear to many of our hearts, those of us who work in these labs.

But I think another point is worth noting, and that is that if our commission had to rank these various issues bearing on education and research, I really do not think that there would be any argument within our group, which is exclusively a university group of people, that fundamentally the need that we face is at the K through 12 level, that we must address that problem first and foremost. If we do not, as Professor Berger said, everything else becomes in a sense secondary.

Senator JEFFORDS. If I may, this is an area I have been very interested in, especially in the facilities and equipment. In fact, I got an amendment into the trade bill to—well, $50 million, which is just a drop in the bucket, at least to get NSF to be looking at trying to do something about what is a multi-billion dollar problem.

Also, it has been raised that there is a very serious lack of equipment, anyway, in the K through 12 area where you need it. Is that also consistent with your findings?

Dr. LESTER. I think we certainly heard much anecdotal evidence during the course of our work that there was, indeed, a serious problem in the K through 12 schools in that regard.

As far as the university facilities are concerned, I would defer to my colleague, who is the director of the computer science lab at MIT on this point.

Dr. DERTOUZOS. In view of the arrival of the vice chairman of the commission and Nobel laureate in economics, Professor Solow, I yield to him.

The CHAIRMAN. I was getting worried.

First, we want to thank you very much. We have had a very good conversation here in view of your comments. We are looking forward to what you might have to say We appreciate very much the very special effort you made to be with us here this afternoon, juggling a lot of different meetings and planes and the rest. But we are very grateful to you for making this effort. It is nice to welcome you and we hope to see you again.

Dr. SOLOW. Thank you, Senator.

I have to apologize for barging in on a hearing like this, but to tell you the truth, what I was doing was teaching, because the last time I heard, that is what was paying my salary And I like to do it.

I presume that you have heard from Michael, from the chairman, most of what is in this report. I primed myself to spend a few minutes talking to you about the fifth of the famous five imperatives in this report, which is something about providing for the future. I wanted to talk about that for three reasons: first, because it is nearest my professional interest as an economist; and, secondly, and most important because it is something that Federal economic policy can affect in a big way, whereas many of the other things that are in this report are not so easily accessible to policy; and, third, after all, it is last on the list, so it seemed pretty natural

I think if you stop someone in the street downstairs and ask them what is meant by investment, the tendency is to think that investment means exchanging one piece of paper for another piece of paper. That is not what we mean by investment. What we mean by investment in the committee and in my business, in the economics profession generally, is spending current resources for future return. And we think, our commission thought, observed—it is not really a thought; it is an observation—that the U.S. is a laggard in investment in the broadest sense. We do not do nearly enough of spending current resources for future return under the general heading of plant and equipment, including infrastructure, public infrastructure, under the heading of research and development, what you might think of as intellectual capital; and, above all, under the heading of human resources or human capital.

Given the definition of investment that we worked on, education and training and research are major forms of investment, and we need them all because they all contribute to the productivity and the competitiveness of our economy.

Investment needs to be adequate in amount and well directed, and public policy has rather more to do with the amount than with the direction. That is probably the way it ought to be, but there are outstanding cases where the Congress, I think and I hope, might like to take a hand in the direction of investment. And the education and training of work people is one of those, and public infrastructure, of course, is another.

I want to say a word about each of those general classes of investment in turn. We spend less on plant and equipment relative to GNP than any of our industrial rivals in the world. You might ask, or God knows lots of people in my business ask, why is that the business of Government? Why is not the market perfectly capable or private industry perfectly capable of investing the right amount for the country? But the amount of even narrowly conceived plant and equipment spending that goes on in our economy is going to affect the earning power of our children and our grandchildren. That would seem, to me at least, to be a legitimate concern for citizens at large.

There are a lot of reasons why we spend so much less on plant and equipment relative to our size than other countries. Some of them are easy to understand, and some are deep and obscure. And I do not pretend to understand them.

The easy part is it is easy to see that a country that for ten years has been operating with a profligate fiscal policy and making up for it with tight money and high interest rates, that an economy like that is going to suppress investment, and that is us.

Or I will give you another example. In the Revenue Act of 1986, the investment tax credit, which I had something to do with originating in the Revenue Act of 1962, the investment tax credit came in for a lot of criticism for having been formulated in such a way that it bore unevenly on different kinds of investment, favored some forms of investment rather than others. Not even a fellow like me would have thought that the natural thing to do would be to fix it, so that it bore more evenly on different forms of investment. But, instead, we repealed it, canceled it altogether, took it out of the code. And so the one explicit, clear act that I can remem-

ber having been done, simply to provide incentive for plant and equipment spending, disappeared just like that.

The CHAIRMAN. Let me ask you, do you notice anything in the research where the repeal of that had any impact in terms of the investment?

Dr. SOLOW. Oh, we did not try to study that. My belief is that general research—this is a problem that interests the economics profession a lot. I am not sure that—only since 1986, we do not have a lot of observation to go on. But when the investment tax credit was first passed in 1962, in the years thereafter there was a lot of research on whether it did, in fact, stimulate investment, and the general verdict was that yes, it did, quite clearly and non-trivially. When I say non-trivially, I mean a lot. That is the way I talk.

A country with as little private saving as we do cannot afford as much public dis-saving as we do. Unlike our rivals, our industrial rivals, Germans and Japanese citizens save like it is going out of style, and their Governments can afford to run large deficits because there is a lot of saving there to dissipate. We do not have that much saving to dissipate.

My only direct experience in government was working for the Council of Economic Advisers during President Kennedy's administration, and during that time, my colleague, one of the members, Jim Tobin—whom you know very well, Senator Kennedy—and I were promoting the idea that the right long-run policy for the U.S. was to run a budget surplus at full employment and use an aggressive low interest rate monetary policy to maintain that full employment. That would be a macroeconomic policy aimed at stimulating investment. To tell you the truth, it would not be a bad policy right now. It would be just as good an idea.

The second form of investment that I wanted to emphasize is R&D, research and development spending. Sometimes I have the feeling in picking up the newspapers or looking at the Congressional Record that it seems dispensable to the Government, it is an easy—R&D spending, research and development spending seems an easy way to pick up a few million dollars here and there, almost as if the Federal Government were a corporation financed by junk bonds.

The natural thing for any restructured corporation that finds itself with a lot of high interest debt is to close down the R&D laboratory. It is the first thing that goes, often enough. It is not going to earn 15 or 18 percent by next year or the year after, when you have to meet the interest payments on that high interest rate debt.

Skimping on R&D spending for a corporation, and I think for the society as well, is like eating the seed corn. It is not a good way to provide for the future.

The CHAIRMAN. Professor, I was just pointing out before you came that it is due to expire now this year, the tax credit

Dr. SOLOW. The R&D tax credit.

The CHAIRMAN. And if it is maintained, it will cost about $3 billion. That is not even in the budget. That has not even been allocated. So if it comes on through, we are going to have to——

Dr. SOLOW. I would like to see it renewed I really and truly would.

The CHAIRMAN Yes. I believe it will be.

Dr. SOLOW. I want to say also a word about human capital, which I presume has been the subject of discussion before I got here. It would be such a natural for this committee. I will not talk about formal education, which is not something I know anything about. We found, our commission found that the training of workers by their employers is an activity in which a market system tends to under-invest. Just as a market system over-pollutes, it under-trains. It tends to spend less than it ought in developing complicated, deep skills in its workers and in renewing those skills from time to time. And we understand why. It is because any business firm has to reckon that it will lose the investment that it makes in many of the people it trains. They may end up working for the rival across town.

We thought, our commission thought that ideas like individual training accounts are interesting and are worth experimenting with, but I think we were more concerned with the system, with the training infrastructure. And there, I think business has to be directly involved. There just is an inevitable tendency for an individual business to "free ride" on the training activities of others. I would do the same if I were faced with that kind of decision.

Maybe that tendency to free ride, and so for everybody to do too little, just the way in pollution everybody free rides on the environment and dumps on it a little bit, maybe we could overcome that by some kind of joint public-private effort. Professor Berger and I were just last night talking about the contrast between the German system and our own, and we do not fully understand why German firms are prepared to make more of an effort to do this sort of training than American firms. Maybe it is because they know that society, including the Government, have arranged things so that everybody will do it, and they will pick up from others about as much as they lose to others.

I do not know how you arrange to do that. I keep wondering, and others in our commission wondered, whether we could use the community college system jointly with local industry to do the training, even if that took some Federal intervention. If it does take Federal intervention, I would always want to make firms themselves contribute so that they care what goes on.

There is always a tendency to milk whatever program there is, rather than to fulfill its deeper purposes. And one way I think of making firms more interested in this sort of training is to insist that they pay for a part of the cost themselves since they will, indeed, benefit a lot.

Well, I am conscious that I came in late, and I do not want to occupy too much of the discussion. I would love, as I imagine other people here would, to answer questions or carry on a conversation or debate, if it comes to that—even with each other. It has been known to happen.

The CHAIRMAN. Well, that is very helpful. We talked a little bit earlier about how we were going to try and attract individuals into the areas of math and science and other technical literacy. I do not know whether you have any comments that you would like to add We heard earlier about whether any suggestions of what the National Science Foundation might be doing more of.

I do not know if there are any insights that you have

Dr. SOLOW. I do not think I have very much to contribute to that. I think that to attract people into the fields of science and engineering, you have to start early. You have to start when they are very young, and I would have thought, for instance, that the sort of things that Woods Hole Oceanographic Institution is about to do in engaging school kids around the country in watching this robot, you know——

The CHAIRMAN. Did they recover the robot?

Dr. SOLOW. They have recovered it, and it will be operating. That by itself is not going to do a thing, but it is going to excite a few thousand kids. And that will count for something.

The CHAIRMAN. Well, we authorized $20 million last year in terms of satellite technology. I call it sort of "Star Schools," to use some of the technology that we have in the military to try and use that for—targeted at least half of it to underserved areas, but also to make available the kinds of experience that I guess Dr. Ballard is going to have in terms of the Mediterranean, which I agree with you. That has been X'd out in terms of the budget, and hopefully we are going to be able to keep that kind of moving along, even at the few million dollar level. But I think that is something certainly that——

Dr. SOLOW. That is important because, as one of my colleagues has just reminded me, one of the shocking statistics is that three-quarters, roughly, of the high school graduates of the country are unprepared to take engineering courses when they get to college. The engineering schools of the country cannot do the remedial teaching. That has to be done in secondary schools and primary schools.

The CHAIRMAN. As you know from those lights, there is a vote, and I will come back for brief additional questions. But when we were talking about the JTPA, over $2 billion we will be reauthorizing, just the use of the funds. They include job search assistance, job counseling, remedial education, basic skills training, institutional skill training, on-the-job training, programs of advanced career training, provides formal combination, on-the-job, and institutional training, internship assignments which prepare individuals for a career, training programs operated by the private sector, outreach to make individuals aware and encourage use of employment and training service, specialized surveys not available through other labor marketing information, upgrading and retraining, education of work transition, literacy training, bilingual work experience, vocational exploration, job development.

We have over a page to try and make it sort of all encompassing, giving maximum flexibility. And, you know, maybe at another time you can kind of get a look at it and check off the ones that you think we ought to be trying to encourage. I think probably the most important is to review the ones which are successful and try and expand those, but just even using your own criteria, which ones might be the most exceptional.

We are just going to recess for a minute. You have been very generous with your time. I just had a couple follow-up questions, and then we will recess the hearing

[Recess.]

The CHAIRMAN We will come to order

I might just ask a general question but one that really relates to at least this committee's jurisdiction, which covers a variety of the different areas which have been pointed out in the study. We have early education programs; we are going to mark up a small program. I call it sort of a Smart Start. It is the High-Line Program; it is the Perry Pre-school Program, Syracuse studies, that demonstrate an appropriate educational component prior to K has had an important impact in terms of helping avoiding dropout as well as many of the other social problems. We are going to be marking that up within the next couple of weeks. We have the "Star Schools" we mentioned earlier, try and use the satellite technology. We have the Chapter 1, the teachers bills. We will have a billion in vocational education. We definitely have that amount of money. It would depend on what we come up with on reauthorization, over $2 billion in the JTPA program.

We have the funding on the NSF. We have been able to get even into this budget—it is a drop in the bucket, but hopefully in excess of $100 million in the areas for new facilities. We have the NIH programs for senior scientists, funding for senior scientists.

So a number of these points that you mention, we are kind of addressing. I suppose the questions is how we can either restructure them, refocus them in a way that is consistent with your recommendations, and that is going to take—we have gotten some good ideas, but that is going to be really something that we have to sort of think about, or whether it is more in terms of resources. Is it more in terms of money?

We did find out that in what they call the discretionary programs, which are about maybe 150, 160 billion dollars, that includes the National Institutes of Health, Legal Service Programs, the Community Health Centers, a variety. But those are considered the discretionary programs. The education programs, the ones I have mentioned here, are all included in those. We were able to increase about $3 billion. So that is an add-on of some minor proportion. At least that is the way we are looking at it over there now.

So is it the money, or is the way these are structured? Or would you have to take a look yourselves and look at them probably in greater detail and see how they are affected? I suppose I am asking about how we can kind of implement these recommendations in these matters which are related to the things which you talked about. That will be something that we certainly want to do. That will be an interest of the committee in doing, and whether we do it very well is something that remains to be seen

Dr. SOLOW. I would ask Suzanne, whose specialty that was, more than mine, to respond.

Dr. BERGER. Maybe I could make three points about this. The list of things that are being done under the aegis of the Job Training Partnership Act and under the Perkins Voc Ed Act are all obviously good programs. So the question really is not so much to identify the bad, but it is try to see whether there might not be some priorities.

I guess as we think about priorities, two points really stand out for us. Some good programs take a long time to produce their fruits. And if you look at the Head Start programs that you men-

tion, in the years that those programs were introduced and their first years of operation, they were often attacked as useless, as wasteful, as not producing any results.

The CHAIRMAN. There are closets full of studies that generally show that they had positive results. Everybody would stick the report away so they would not have to face it.

Dr. BERGER. Now, as we look at how long-lasting some of those results were in students in whom those investments were made, you realize that sometimes it takes a long time for the full fruits of an investment in an educational program to be realized.

So I guess one of the things we would say is perhaps the point is not so much to change some of the programs that have been introduced, but as in the case of the Job Training Partnership Act to try to see which parts of it ought to be reinforced and which of the existing mechanisms could be strengthened in order to produce better coordination among the parts.

Take, for example, the Private Industry Councils, which exist now but are often so under-funded, have such weak capacity for, in fact, coordinating some of the activities on the side of vocational education and on the side of job retraining, that rather than invent a new mechanism we really wondered whether we should not really think of how to beef up industry participation, how to produce more participation of small and medium size industries within those organizations, how to produce a more effective coordination between existing Federal programs in the voc ed and retraining area.

Too often, coordination today seems to be nothing more than institutions sending each other plans at a point at which no real effective coordination of efforts is possible. That would be the first point. We would see a beefing up of those coordinating mechanisms, like the Private Industry Councils, in which you do have the possibility of creating something somewhat similar to what the Germans have with their coordination between unions, which have not been large enough players in these institutions, industry and Government, and trying to talk about what the curricula might be for voc ed and for job retraining efforts.

The second point, I think, has to do with the lack of a strategic vision. The next to the last of our recommendations about the world economy does focus on what we see as an absolute imperative to internationalize the perspective of Americans. When I think about Federal programs that used to exist in this area—for example, for foreign language training—programs which then were justified by national security imperatives, today, in fact, our survival as an economy depends on our ability to sell in the world economy. And some of these Federal programs for foreign language probably should be reintroduced in this time not so much out of national security as out of economic reasons

So those would be some of the things that we might have in mind along these lines.

The CHAIRMAN. Okay. Well, we will be listening as we come up to deal with these programs We will be trying to keep in mind, I think, not only the comments today, but the excellent recommendations in this book.

Let me ask you. Professor Solow. Earlier I asked a question about why this study, report, is special, and Professor Dertouzos reminded us and gave a good response. You certainly have seen various reports come and go. Is there anything that you want to just add on?

Dr. SOLOW. The last time I tried in a few sentences to describe what was special about this report, I took a beating for it. [Laughter.]

I will not try that——

The CHAIRMAN. I do not know whether I can take this about the doctor and go all the way through that.

Dr. SOLOW. No, no. I had a much more pungent description, but maybe—I think what is special about what this group has done is, first of all, its composition; that fact that what you got here are engineers and scientists and computer jockeys and economists and political scientists.

The thing was done not by a narrowly focused group but by people of a wide range of things, including experience in industry. College professors often consult too much, but one of the things they get out of it is some knowledge of what the real world is like. And that helped. And the fact that we were able from using that to build the thing up from a study of some particular American industries is rather different.

I ended up with ideas somewhat different from those that I came in with, and that is rare for anybody and rare for me.

The CHAIRMAN. Open-minded as you are.

Dr. SOLOW. Yes. And I think that we have tried to study a lot of facts, filter a lot of ideas, and arrange them in a meaningful way. That is the best we could do.

The CHAIRMAN. Okay. Well, I want to thank you all. I know that you are hard pressed as you present these conclusions. We have all seen the very significant amount of attention that they have received in terms of the public. This committee that is primarily focused on the old area of human investment wants to try and see how we can adopt these to the current conditions. We are, as I said, enormously grateful to you.

Professor Dertouzos, is there any final comments that you would like to make?

Dr. DERTOUZOS. Perhaps 30 seconds, Mr. Chairman. Just to wrap up, I would like to say that there is no question that the U.S. is in serious trouble with respect to its industrial performance, and a major factor in this is our neglect of our human resources.

Second, if we do not mend our ways in improving this problem, then every American will feel it as a reduction of the standard of living. And the Nation will become impoverished relative to other nations.

Third, to mend our ways, we need to pursue all five of the imperatives that we brought to you. The most important of these is the human resource side and the education of our people, both at school and at work.

We are very optimistic in the commission, Mr Chairman, that this young Nation, with the diversity of its population, can, indeed, arise to the challenge and address this problem. And we wish you and your committee, which will play such an important role in the

human resource and labor aspects, the best of luck, and we wish you well in this quest.

Thank you on behalf of all of us.

The CHAIRMAN. Well, I thank you. We do not want to let you escape here with the idea that you are not going to be hearing from us and that we are not going to be calling on you, because we are as we come to grips with it. We are going to be very grateful to you for the presentation today and also to your future help and assistance.

The committee stands in recess.

[Whereupon, at 4:45 p.m., the committee was adjourned, subject to the call of the Chair.]

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