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TECHNOLOGICAL INNOVATION AND THE U.S. ECONOMY

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NATIONAL ACADEMY OF SCIENCES AUDITORIUM
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INTRODUCTION

PHILIP HANDLER
PRESIDENT
NATIONAL ACADEMY OF SCIENCES

It is my pleasure to welcome you to this evening on Technological Innovation and the U.S. Economy. We began our series of Forums several years ago to provide an opportunity for the airing of controversial issues that affect our national life and involve the uses of science and technology. Forums have lasted variously from two and a half days at the one extreme to this evening's miniforum at the other. This is our first experiment in this format. I trust that it will be successful, and I am delighted that so many of you are willing to give your evening to this endeavor.

The topic of technological innovation is on the front page of the newspaper day after day. It is debated on talk shows, a concern of the Congress, and a central concern of the Executive Branch, as most of you will know. Because it is somehow in the nature of our national heritage to identify good guys and bad guys, we seem to approach the problem of technological innovation in the same way. Much of the discourse about the problem has to do with what went wrong. Life was just great in the 50's and early 60's; what has happened to it?

Why is it that the United States appears to have lost its competitive advantage in the technological industry, at least in some areas? What can we do about it?

Among the blame-casters we find those who would place the onus on the ineffectiveness of American R&D, our tax policies, our regulators, the sloth of American industry, poor management decisions, labor and its demands for higher wages, and easiest of all, the effects of inflation; i.e., when the prime rate is 10 percent, life is just very different than when the prime rate is 5 percent.

Quite possibly there may be some truth in all of the allegations, but none of them have seemed to me to really clarify what the problem is actually about. It is certainly clear that if American streets did not abound in Datsuns, Toyotas, Mercedes, and Hondas, if most of our purchases of household electronics were those made by General Electric, Westinghouse, and Zenith rather than by Sony and Panasonic, if those cameras and pocket calculators we carry were of domestic manufacture, if, in short, our international balance of payments were positive rather than negative, we would feel rather differently about this. It is our large deficit in international trade that has turned our attention inward to see why we have arrived at the present state of affairs, to ask ourselves what this state of affairs really is, and

then to ask what policies, at the national or local level, might improve the circumstances that appear to give us trouble.

How this will come out this evening, we shall each learn for ourselves. Our advisory committee has assembled a stellar panel to present one set of views for you; I hope that there will be plenty of time for all of you to contribute yours before we are finished. I will be satisfied if there is as much light as there is heat before the evening is over. To tell you how we are going to go about this, I would like to introduce Dr. Robert White, who is in charge of this Forum series for the Academies.

ROBERT R. WHITE
DIRECTOR
THE ACADEMY FORUM

As the audience is an important part of the Forum, we invite your vigorous and full participation. We will ask you when you do participate to identify yourself rather clearly with your name and affiliation. These proceedings will be taped, transcribed, and then edited. The resulting document will be delivered to the Assistant Secretary for Science and Technology in the Department of Commerce for use in connection with various workshops and meetings among the groups now active in the 28-agency

review of the topic.

I would like to express particular gratitude and recognition to Hugh Miller, the Executive Director of the Office of the Foreign Secretary at the National Academy of Engineering, for his encouragement and assistance in putting this evening together. For the past three years, in cooperation with the National Research Council's Assembly of Engineering, he has gone rather deeply into the evening's subject and peripheral subjects with workshops and studies on technology, international economic and trade issues. We are very grateful for his help because it was unusually effective.

In view of the collegial relationship between the National Academy of Engineering and the National Academy of Sciences, it is rather appropriate that your moderator of the evening has been elected separately and specifically to each of these institutions. He is an engineer, a physicist, a biophysicist and a Nobel Laureate of physics for 1973. I take great pride and personal pleasure in introducing to you the helmsman for the evening, your moderator, Dr. Ivar Giaever.

IVAR GIAEVER
RESEARCH AND DEVELOPMENT CENTER
GENERAL ELECTRIC COMPANY

I would like to reiterate Dr. White's and

President Handler's remarks and welcome you all to this Academy Forum on Technological Innovation and the United States Economy. As you heard, this Forum is an innovative step in itself because for the first time we have an entire Forum in a single evening. As it is not a narrow subject we are going to address, I am sure it will be a very busy evening, and I hope a very interesting one.

I am going to start with introducing the panel to you, and I will ask them to come up and be seated on the stage as I do so.

The first is Joseph Cordes, who is an Assistant Professor in Economics at George Washington University. In relation to his specialization in public finance and his interest in the economics of technological change, Dr. Cordes has worked with the experimental technology incentives program of the U.S. Department of Commerce.

The second panel member is N. Bruce Hannay, Vice President for Research and Patents, Bell Laboratories. As Foreign Secretary of the National Academy of Engineering and a member of the National Academy of Sciences, Dr. Hannay has been involved in a variety of activities relating to technological innovation.

Next we have Ralph Landau, who is Chairman of the Board and Chief Executive Officer of Halcon International, Incorporated. Dr. Landau is a chemical engineer and a leader

in the application of chemical process technology in the United States, Europe, and Japan.

Then we have Harrison Schmitt, who, I have been told, is called Jack. He is a United States Senator from New Mexico, and a ranking minority member of the Science, Technology and Space Subcommittee of the Senate Committee on Commerce, Science, and Transportation. He is also an astronaut, and apparently the only scientist to have walked on the moon.

Finally, we have Elmer Staats, who is the Comptroller General of the United States. He has a long and intensive range of experience in activities that directly relate to handling the government's money and monitoring its spending.

In addition to these distinguished panel members we have three discussants for the evening who are seated in the front row. As I read their names I will ask them to stand up and be recognized: Nathan Rosenberg is a Professor of Economics at Stanford University; James Hillier, retired Executive Vice President and Senior Scientist at RCA Corporation; and Aaron Gellman, President of Gellman Research Associates.

Now you may be wondering what I am doing up here as moderator for this distinguished panel. I have to admit that I wonder about that myself, because I have very little

background in these kinds of activities. True, at one time I worked as a Norwegian patent examiner, and I learned one thing: There is very little correlation between patents and inventions. Although you may think that there is a one-to-one correlation, there certainly is not. As a matter of fact, most important inventions cannot be patented. I am thinking about inventions in the social sector, for example, like the public school system, which certainly is an invention. The playing of music over a radio is an invention; granting patents to inventors is an invention. Even giving a marriage license is an invention. I think getting children is a discovery, but I am not going to go into that.

Patents as we are going to talk about them really deal with technology, the subject of this evening's session. If you are not familiar with patents, you may not know that most patents really deal with very small steps. Unfortunately, very often these steps are backwards as well as forwards. Very rarely do we deal with major technological breakthroughs, which is what we all are looking for.

In my lifetime, for example, some famous examples were the concept and the realization of nuclear energy, or the transistor and the integrated circuits, or the Xerox process and the television set. We all know that these have

had a profound impact on the way we live, and also have had a profound impact on the United States economy.

But somehow we always take it for granted that these things were realized in the United States. This has always been true. Yankee ingenuity, coupled with the American economy that has been vital enough to bring these ideas to the marketplace has made it so.

I am sorry that I have to blow Edison's cover, but you probably think that he invented the incandescent lamp. He did no such thing. But he carried through the innovation of the incandescent lamp. He was the first person to make a lamp that lasted; he made generators that were practical; and he introduced the central power station. But the lamp was invented 40 years before his time.

Invention generally is a clever idea that doesn't cost much money. But to take an invention and make it into an innovation and take the idea to the marketplace generally accounts for maybe 95 to 98 percent of the total amount of money.

Right after I accepted to be a moderator tonight, Time carried an article called "The Innovation Recession." Spectrum carried a whole issue called "Productivity." I take that to mean that we all are concerned about the lack of productivity and the changing of the climate in the United States. This particular Forum is one such example.

Of course, then we have a dialogue. The United States of America is a very open society, and one of the few societies which is willing to examine itself critically. One of the results of such a dialogue, for example, is that we now pay much more attention to the environment than we used to do. Of course, you have to realize that only rich nations can pay attention to pollution. As America is a rich nation, I think it is proper that we do so.

Another thing you should realize is that only an infinite amount of money can make it perfectly safe for you, and therefore we have to learn to make the proper compromises in the rules and laws that govern and guide us all.

Another result of such a dialogue which bothers me because I am a technologist -- and this dialogue often takes on almost the fervor of religious wars -- is that America is backing away from technology. For example, the supersonic airplanes that cross the Atlantic are not made in the United States. There is general agreement that the breeder reactor can provide energy for us all in the foreseeable future, but we have chosen to back away from that technology. We have left it to the French and the Russians. This is by choice.

To take an example on a more modest scale, I can mention the video tape recorder for home use. It is

expected to be a large consumer item in the United States, and none of them are made in America; they are mostly made in Japan. So here, industry apparently chose not to compete.

Well, what I want to bring home with all of that is that while innovations affect the economy, the reverse is equally true. The economic climate affects the amount of innovations we do. At the present time, if you use the stock market as an indicator or if you use the declining dollars in the foreign market as an indicator, apparently America is not doing so well.

Now, I don't know what the reasons are for that. It could be the high inflation rate, it could be lack of venture capital, it could be the tax structure, or it could be just a general uncertainty about the future. I hope these are some of the issues that will be discussed tonight. Of course, there are no simple answers, and I join Philip Handler in saying I hope there will be more light than heat when the evening is over.

STATEMENT OF N. BRUCE HANNAY
VICE PRESIDENT, RESEARCH AND PATENTS
BELL LABORATORIES

Both Dr. Handler and Dr. Giaever commented on the relative amounts of light and heat that we are likely to hear tonight, which reminds me of the unkind critic of Washington, who remarked that the laws of physics didn't apply in Washington because it was the only place in the

world where it had been observed that sound travels faster than light.

The national performance in technological innovation has become a matter of great concern, and it is talked about a great deal these days. Not only is it widely talked about, but something might even be done about it. The reason for this, as I am sure most of you know, is that there has begun in the federal government a domestic policy review under the general direction of Juanita Kreps, the Secretary of Commerce; it was instituted by Frank Press, the President's Science Advisor, and is in the hands of Jordan Baruch, Assistant Secretary of Commerce for Science and Technology. This exercise will produce an options paper for the President next spring, dealing with technological innovation.

Given this amount of interest in the subject and this activity, it is legitimate to ask what is innovation, and what is the reason for all of this concern. Dr. Giaever has described in a very picturesque way what innovation is, and made it clear that it is a term that has come to be used as a description of the total process of converting a technically new idea into something that can be delivered to an ultimate user. It really is far more than the research and development that scientists and engineers have been concerned with, because it includes

engineering, manufacturing, marketing and financing.

Now, the reasons for the concern over the innovation rate in the United States fall into several categories. One of them stems from a collection of economic data, and these include such matters as the low growth rate for the gross national product in the United States as compared with that in other industrialized countries. There is a low rate of increase in the productivity, and indeed, the productivity increase in the United States is at a lower rate than that of the other major industrialized countries.

We have huge trade deficits, and we find that when we examine these carefully that our trade balance is positive in technologically intensive industries, and it is generally in the less technologically intensive industries, where we believe that the innovation is most lacking, that we have the biggest deficits. And together they add up to an enormous deficit. So there are economic data.

There are also statistics that relate to the R&D activity in the country. These show that the R&D in the United States as a percentage of the gross national product has been in a rather strong decline for quite some time, and when we compare it with countries like Japan and West Germany, which do not have a significant fraction

of their R&D in defense and space, the figures are even more striking as far as the civilian sector is concerned.

There is also a very high degree of concentration of our research and development in a few industries, and even in a few companies, and there are large segments of industry which are really not active to any significant degree in the R&D process.

When one looks at the basic research in industry, there has been a substantial decline in real dollars in the last ten years, and the concentration of the basic research is even more apparent than for the total R&D. So there are these R&D statistics.

The third measure of the decline in our innovative strength is a more qualitative kind of observation, and in a way I think it is the most important way to look at it, although it is difficult to measure. This is that I see in the industrial research scene a greatly shortened time horizon in many companies. There has developed a concentration on what we call incremental innovations, which are really fairly modest steps forward, and on cost reductions, and a corresponding decline in the effort on major innovations. By a major innovation I mean one which really produces an entirely new technology or an entirely new class of products or services.

I should qualify my remark and say that while I

make these statements as a general observation on the industrial scene, it is very industry- and company-specific. There still are industries -- electronics, for example -- and companies which are completely committed to major kinds of innovation. What I am concerned with, however, is that looking at the broad range of American industry, there has been some decline.

What are the reasons for the decline? Well, we are going to talk a lot about that, but some of them are internal to a company. I think that many businesses have a management which has too great a concern for today's bottom line as compared with the bottom line that they are going to see in future years. And this has led them to a short-term perspective. But also, according to industry, a considerable part of the reason is to be found in federal policies and actions. There are two principal areas in which industry feels that these have led to a decline in our innovation.

One is the field of regulation, which leads to a diversion of research and development funds to work that is designed specifically to meet regulations and is not otherwise productive. It leads to a diversion of capital funds, and we will hear more about the importance of having capital funds for investment in new plant.

There is a very substantial portion of the GNP

that is going into the meeting of regulations. It has been variously estimated upwards from $100 billion, and you read all kinds of figures about how much of this is essentially wasted because it is unproductive, how much of it is unwise, how much of it is unnecessary. The fact is that regulation clearly is a necessary part of our life, but we are not doing it very well. So the issue is not whether or not we should regulate, but how can we do it better.

Another area seen as a major one by industry is financial and tax factors that affect investment. Here we have a variety of economic circumstances: high and variable inflation rates; the cost of capital; interest rates that are manipulated and often high. There are a variety of things that fall in the category of tax policy: capital gains, depreciation, investment tax credit, double tax on dividends, all of which have an important effect on the willingness of individuals and corporations to invest.

Now there are factors other than regulation and financial ones. There are antitrust, patent policies and others. But I think those two are the primary ones, although each industry or company has its own preference. One thing that can be said about both regulation and the financial and tax area is that as much as anything it is uncertainty that affects the willingness of industry to expend its funds over

the long term, where the return is going to come six or eight years from now, rather than next year. There is uncertainty over what the new regulations will be, and what the financial, economic and tax climate will be. Given this extra degree of uncertainty, why spend your money on a new plant that isn't going to bring a return until six or eight years have passed, when you can spend it on cost reductions and see the return next year?

Well, what can be done about all of this, or what should be done about it? Again speaking of the general views of industry, people in industry feel that there is a decrease in incentives; what they would like is a restoration of incentives. To put it more precisely, they would like a removal of disincentives that flow from federal interventions in the innovation process. Industry believes that the federal policy should be to encourage the private sector to invest its own resources by allowing a fair reward for that investment.

Let me say, quite specifically, that what industry does not say it needs is more federally sponsored, federally funded R&D in the application of science for the civilian sector. That is not what is usually said when people come to Washington; they usually are advocating the expenditure of more funds. That is not the cure in this case, because the absence of the R&D on long-range innovation

is a symptom rather than the problem in and of itself. When the climate is right so that it appears worthwhile to industry to invest in major innovations and for the longer term, then industry will itself provide the funds for the R&D that will start this innovation process.

STATEMENT OF JOSEPH CORDES
PROFESSOR OF ECONOMICS
GEORGE WASHINGTON UNIVERSITY

Since I am representing the academic community on the panel, my initial remarks will focus on some findings from the economics literature on technological innovation that I believe are particularly relevant for public policy. The audience, however, should realize that a capsule survey of all the literature on the economics of technological innovation cannot be provided in five or ten minutes.

I will begin by discussing research concerning the economic impact of innovation. The empirical literature in this area seems to agree on two major points.

The first point is that the economic returns to innovation, both those captured by the innovator and by society as a whole, are on the average quite substantial. The second point is that these rate-of-return calculations often reveal a divergence between what economists regard as the full economic or social value of the innovation, and the private return that the innovator actually receives. The reason for this result is that innovations often provide

spill-over benefits to third parties who don't necessarily share in the cost of the initial innovation.

Significantly less certainty exists about the precise determinants of innovation. This is clearly an area in which the standard academic plea would be for further research. I believe that such research is essential if public policy toward innovation is to be properly formulated.

Nevertheless, a number of recurring themes about the determinants of innovation appear in the economic literature. I would like to summarize three that have rather direct implications for public policy.

One finding, largely due to Professor Jacob Schmookler, is that innovation is at least partially induced by demand factors. In particular, empirical evidence suggests that the demand for capital equipment is an important determinant of capital goods innovations. A second finding of a number of studies is that R&D intensity, and therefore, at least implicitly, innovative activity, is significantly and positively affected by liquidity and/or cash flow considerations. That is, the willingness of firms to invest in the development of innovations may be influenced by the ability of those firms to finance such activities through internally rather than externally generated funds.

Finally, both casual observation and empirical

evidence seem to suggest, as has Dr. Hannay, that certain economic factors are more likely to be involved in the innovation process than others. At the industry level, we know there are a handful of industries that have traditionally played a more important role in this process than others. If we look at the level of the individual firm, the evidence suggests fairly strongly that small entrepreneurial firms play an important role in the overall process by which an idea is transformed from an idea into a commercially viable innovation. This does not necessarily mean that small firms are always responsible for initiating the idea. However, they clearly play a fairly important role at some point in the process of creating an innovation.

I will now briefly comment on what is relevant about these findings. The first point is that evidence about the contribution of innovation to economic growth and productivity indicates that there are good economic reasons for concern when the available indicators just mentioned by Dr. Hannay point to reductions in the commitment of resources to innovation. There are some potentially large economic benefits that may be foregone as a result of such reductions.

A second point is that the observed gap between the return received by the innovator and by society as a

whole is a fairly classic example of a private market failure. Whenever individuals or firms are not able to capture the full economic value of their endeavors in the marketplace, economic theory predicts that too few resources will be devoted to such endeavors. In such cases, incentives provided by the public sector may be warranted in order to achieve a more desirable allocation of resources.

However, economists, perhaps uncharacteristically, are rather cautious in using these findings as a basis for prescribing specific policy interventions that might be used to stimulate innovation. In my own opinion, there are perhaps two major reasons for this reluctance to make specific policy recommendations. One reason is that a number of studies have shown that R&D conducted either strictly on behalf of the government or with a heavy infusion of government funds, seems to generate lower returns than R&D activities that are more or less strictly private in nature. Additionally, for purposes of designing subsidies that are at all cost effective it is necessary to define exactly what is to be subsidized. It is, however, very hard to measure the output of the innovation process. We have some notion that certain inputs, such as R&D, are more likely to be used in the process of generating innovation. Perhaps

these are viable candidates for subsidies of a certain type. Indeed, such subsidies are already provided in the tax system. However, it is difficult to prescribe specific policies for subsidizing innovation per se.

Where does this leave us? Do these remarks mean that public policy is totally incapable of influencing the course of innovative activity? I think not, for reasons that are consistent with some of the remarks that have just been made. First of all, there are instances where public policies have created disincentives that have discouraged innovation. Certainly whenever such cases can be identified, there is reason for recommending changes in those policies. Moreover, it is possible to make some positive recommendations based on what we do know about the innovation process. Specifically, we can identify some determinants of innovative effort such as those I have mentioned. We also have some idea about how these determinants of innovation are affected by certain public policies. With this information we therefore have some basis for recommending policy changes that may provide a more favorable climate for the innovation process.

Hopefully, we will be able to examine such policy changes in more detail in the discussion. However, I will conclude my remarks by offering a specific example.

Earlier I noted that an empirical relationship has been observed between the amount of capital spending in the private sector and the amount of capital goods innovation. Tax economists have devoted considerable effort to analyzing how corporte investment decisions are affected by the federal tax system. We have reason to believe that there are certain policy measures such as investment tax credits, and guidelines governing allowable depreciation for structures and capital equipment that have a discernible impact on capital spending decisions. Hence, changes in these aspects of the federal corporation income tax are likely to affect an important determinant of innovative activity, namely overall capital spending in the economy, and thereby should also have a discernible effect on the amount of investment and innovation undertaken in private industry.

It must, of course, be recognized that political considerations may preclude certain general changes in tax policy. In such cases, specific tax incentives, such as expanding tax write-offs for R&D expenditures, may be the only feasible means of providing some fiscal stimulus for innovation. However, the available evidence indicates that the most sensible tax policies would be those that influence certain general economic variables that affect innovation in private industry, rather than a variety of specific

policies aimed at either specific industries, or specific types of spending that at least putatively are labeled as innovative.

STATEMENT OF RALPH LANDAU
CHAIRMAN OF THE BOARD AND CHIEF EXECUTIVE OFFICER
HALCON INTERNATIONAL, INCORPORATED

I would like to briefly comment on our moderator's definitions of invention and innovation, which I think are very important to keep in mind, because they get very confused in the general press. I think that I am correct in saying that economists define an innovation as the first commercial application of a new or improved process or product. I would extend that definition to include a system, just as Dr. Giaever said. So that the innovative process consists of two stages: the conception or the invention of the new or improved process, product or system; and secondly, the subsequent commercialization of the new or improved process, product or system.

I think I am also correct in saying that the economist would say that an invention by itself is not an economic good. It is only by its commercialization that it becomes one.

The words "entrepreneur" or "entrepreneurship" are a somewhat different concept. Entrepreneurship is the process whereby people, money, markets, production facilities and knowledge are brought together by an entrepreneur

to create a commercial entity or enterprise which did not exist before. It does not have to embody an invention. It can be the founding of a new drycleaning establishment on a block, or a new plant by a corporation using existing technology.

If, however, a technological or other invention is involved in this entrepreneurial activity, the importance of it is even greater, because its success completes the invention and makes the innovation. As Professor Harvey Brooks has said in the past, the technical entrepreneur spearheads the technological innovation process. And in my experience, and I think in most other observers', he must be closely coupled to the market to be effective.

Usually the inventor and the entrepreneur are not the same people, although in rare cases they are. There are subclasses of innovation such as individual inventors, corporate inventors, the inventor/entrepreneur, and the technological entrepreneur. I happen to be one of the latter, and therefore, as our moderator said, my views basically reflect what I like to call the worm's eye view of economics. I think economists call it microeconomics, but I look at it very simply. We are at the bottom of the barrel, and we are looking up at all the rules and regulations and guidelines that have been set up for us by those above us. How do we react to situations of this kind,

and what do we do to get out from under some of the bad things, and how do we take advantage of the good things?

I started a small company, exceedingly small at the beginning, but it is not so small now. And over the 32 years I have gotten the perspective of being a technological entrepreneur. But at the same time I am very fortunate in that I am also a chief executive officer of a company that spends a lot of capital. In our partnership with Atlantic Richfield I have a close perspective on what a large oil company does about its capital formation and priorities. And as a director of Alcoa I am very well acquainted with what a highly capital-intensive industry does. Therefore, I can only echo what has been said before: Every case is really different, and it is very dangerous to extrapolate from one's own personal experiences, or even from those of economists, who are generally much wiser than we are.

I do not want, however, to claim that all innovation is by smaller companies, or necessarily that market forces are always the source of innovation. There are innovations and learning curves at most large companies, although indeed, statistics do show that smaller ones have perhaps been relatively more innovative. And certainly my friend Bruce Hannay from Bell Laboratories will be too modest to express the fact that Bell has one of the

most extraordinary records in the production of new ideas, even though our government is attempting to call AT&T a monopoly.

I think you have heard adequately the statement that the invention part of the innovation is generally a very small part of the total capital investment, or the total cost of creating the first commercialization. Edwin Mansfield has studied this in some detail, and he comes out with a variation ranging from as little as 10 percent to as high as 71 percent in some of the instances he looked at. You can well imagine that in a pharmaceutical company where a new drug is involved, it could easily require an enormous amount for the introduction of a new product, but a relatively small capital investment to establish it.

In any event, the average of the innovations that he studied were overall about 39 percent. If it is a new process it will be substantially less than that; if it is a very complex product it will be more than that.

The important conclusion is that the invention in almost every case costs substantially less than half of the total amount to complete the innovation. As a result it is only now that we in the United States are starting to probe into the reasons for our apparent decline in innovation.

What we have discovered, as you have heard, and certainly I concur, is that the risk-taking entrepreneurial side of the process costs a greater part of the innovation, and it is the part that has been faltering, even more than the R&D expenditures per se, although you have heard these have been declining slowly as a percent of GNP in real terms.

Professor Rosenberg of Stanford University has pointed out that the machine-based technology that emerged in the nineteenth century owed relatively little to scientific knowledge. While the mechanization has continued into the twentieth century, a succession of new sources of technology has developed: chemical, electric, electronic, biological, nuclear, for example, each of which requires a scientific base for technological achievement rather than cut-and-dry empiricism.

Nevertheless, it is important to realize that often technological development led to important scientific discoveries. Indeed, sometimes the invention never did have a complete scientific understanding, or it generated its own science afterward. It is a mistake, therefore, to link innovation too closely to basic scientific research, and I don't think our theme tonight deals with that latter subject, although a linkage does exist in the long run, in a series of what Professor Rosenberg calls feedback loops.

In our country the great successes and dominance of our technology since the Second World War have blinded us to the changes that are taking place, both internally and externally. I have often raised this question with my economist friends: How much of the growth of the American GNP since World War I or II has been due to technology, and how much of our annual rate of growth in GNP is due to technology?

The measurements, as you can well imagine, are extremely difficult. I would say that I have seen estimates that range all the way from 25 to 90 percent for the first, with approximately 40 or 45 percent as a middle ground, and perhaps one-third to one-half for the second. I think these numbers in general understate the true facts, because the quality of new products and of new capital investment cannot readily be measured. But clearly, technology is the one single factor that has been the major contributor to the advances in the American standard of living since the middle of the last century.

Dr. Nordhaus, who is a member of the Council of Economic Advisors currently, has said that the effect of technological change substantially outweighs that of increases in capital stock, and it also outweighs that of increases in the labor force. This is a very important

and significant finding for public policy.

You have heard the previous speakers give you some indications of why it is that despite all these great things we have done, we are faltering today. I certainly don't want to enlarge on the matter of balance of payments and inflation, and reduction in growth rates, and decline in productivity, et cetera. I think it is important to say that I see all of these same phenomena as economists see them. What we necessarily don't agree on is the remedies in each particular case.

But I believe that the basic reason for these trends has been in the failure of our political system to understand the really revolutionary, positive role of technology, at least in late years. The negative side has been much too overemphasized in the recent past, although there certainly is a negative side, and this has resulted in overregulation and contradictory regulation.

Simultaneously, taxation on individuals and companies taking risks has increased. Most of the technological progress made in this country was accomplished in an era of few taxes and minimal regulation, and I can tell you, I remember those days very well; they weren't so long ago.

Partially the current trend toward egalitarianism, to the redistribution of wealth, has contributed to the

present situation, and yet we have never been in greater need of innovation, particularly because the problems cited are not susceptible to the standard quick fixes of fiscal and monetary policy, or wage and price controls, or restrictions on the movement of goods, services and capital across international boundaries, et cetera.

I have previously, on this very platform, participated in a National Academy of Engineering symposium of innovators and entrepreneurs. The basic point of that symposium was that we must restore incentives, or as Professor Cordes says, reduce disincentives, to make innovators take risks. We must restore incentives which have been steadily eroded for over 20 years without really realizing what the ultimate effects would be.

The 1978 tax bill, which has just been signed, contains significant changes in favor of risk taking such as the lower capital gains taxes, the stepup in tax rates for smaller companies, the investment credit being made permanent and applicable to 90 percent of profits instead of 50, and so on. This shows that the political community can respond rapidly when a real need is recognized, and those who perceive it work hard enough to impress it upon the politicians.

But in general, history shows that socioeconomic trends take many years to emerge. I would like to be able

to have the time to study the problems of other countries, and how differently the history of each one has gone. But in any event, I am convinced that when risk taking is adequately rewarded, invention will start to increase also.

I agree with Professor Mansfield that government cannot really contribute effectively to the R&D efforts of the private sector, and I am glad that Bruce Hannay has said the same thing. The private sector must be closely coupled to the market. Rather, the solution lies in reducing the attacks and regulatory burdens on the innovator, so that risk taking may become more profitable. There will soon enough be heightened attempts at invention. The American people are good at both invention and entrepreneurship, given a chance. Our history certainly proves it. Professor Rosenberg has written some fascinating accounts of that history.

I would like to conclude by saying that no better contrast to our historic aptitudes in this regard exists than the experience of the Soviet Union, which outlaws entrepreneurship and decentralization in favor of central planning. A recent book, called The Technological Level of Soviet Industry, contains a chapter on the chemical industry, which happens to be the one I am involved in. The author's conclusion is simple: Compared with most

western countries, the Soviet research effort and total output of scientific papers are probably considerable, but the overall quality is such that it does not appear to have made a proportionate impact on world science. Also, the Soviet research effort does not seem to have generated any really important and original innovation which could be successfully scaled up to mass production.

Our company has personal experience in some of these matters since we are doing several projects in the Soviet Union, and I think the author has hit the nail on the head. There is no pattern of innovation in their industry for reasons that must be obvious to everyone. The penalties of failure far outweigh the rewards of success! It is much safer to buy complete plants and the financing that goes with them from the West.

On the other hand, they have very good chemists and they do a lot of good work. This underlines the great distinction between research and invention on the one hand, which is basically not an economic good at all, and innovation, which is completion of the invention by entrepreneurial activity and its first commercialization. Only then does it become an economic benefit to society.

STATEMENT OF HARRISON H. SCHMITT
UNITED STATES SENATOR
FROM THE STATE OF NEW MEXICO

This very important issue of innovation is one

which is a problem because of what Ralph Landau has indicated: It is extraordinarily difficult to exchange information between those who are part of or understand innovation, and those who are part of or understand the making of policy and legislation that may affect it.

Congress is being exposed in an increasing way to some of the issues of research, technology, invention and innovation. In the Subcommittee on Science, Technology and Space, on which I am the ranking member, we have undertaken, with Chairman Stevenson, a number of hearings that deal with general policy issues, such as recombinant DNA or the technology and scientific base for nuclear waste management, disposal and/or utilization. Since both Senator Stevenson and I sit on the Banking Committee and on the Subcommittee on International Finance, we jointly held hearings on export policy in which this was the specific issue that was treated, namely, the role of innovation and its relation to export policy.

In general I would say that because of the very broad range of measures that were treated in the 95th Congress, both in committee and on the floor, that the Congress has been exposed in an increasing way to the issues and to some of the discussions that relate to technology, invention, innovation, and other factors associated with those items.

One of the problems we still face within the Congress, and will face, I am afraid, for some time -- and one we also face within the media with some outstanding exceptions -- is an antipathy toward things that we don't understand. Many of you have been exposed to Golden Fleece Awards, to the efforts to cut appropriations in areas of basic scientific research or even of basic technology research. This problem of how we deal with people who feel an antipathy toward things they don't understand is a very fundamental one in relation to the subject before us.

We can gradually broaden the base of experience and background within the Congress and within the political process. We must continue to work to improve the general educational level of our population and those to whom politicians must respond. But it is going to take the individual effort of everyone in this room and in this country who is associated with technology, with invention, with innovation, entrepreneurship, to conduct his or her own personal educational process wherever they have some influence.

I would like to set some historical perspective about the role which major federal projects or federally sponsored projects have played in developing a technology base. Although these may or may not show up in the economic studies, they generally are understood to have expanded the

base from which we innovate. The most obvious example is the space program, one with which I was closely associated.

Other general examples have been wars. These also are federal efforts that raise the base of technology, unfortunately at an extreme cost of human life. But we would be less than realistic if we didn't realize that this has happened in the past. Hopefully with other endeavors, we can remove war as a source of technological innovation.

Some of us, in the heat of the debate on the Panama Canal, were made aware of the role that that federally sponsored project played in technological innovation in its time, in the steel industry, in the electrical power industry, in automated control of various components associated with that major federal effort.

We can go back even farther in history and pick out examples. One that comes to mind immediately is that of the transcontinental railroad, which was obviously federally sponsored. Although it was quite controversial in its time, the federal government did back it.

All of these did add to the total technology base from which this country grew, and grew very rapidly throughout its first 200 years, and is continuing to grow. One of the questions is: What is the relationship of major federal efforts to stimulate technological growth in our present economic dilemmas and dilemmas of international policy?

As an aside almost, but as a very important aside, we must realize that properly conceived federal investments in technology, in research and development, in research itself but with a longer time constant, investments of that kind are fundamentally deflationary. It is one of the few direct things that the federal government can do by spending money that over a relatively short period of time institute deflationary forces within our society. By an increase in goods and services that come from new technologies we do create a way of using up an excess money supply, which is in one way or another one of the fundamental -- if not the fundamental -- causes of present day inflation.

So I become very disturbed when I hear statements that all aspects of the federal budget, which is in deficit, are going to be cut equally, or have to bear the same burden as other aspects of it. That is an extremely short-sighted view of the differences in the nature of federal expenditures. Again, I would urge all of you to help some of us on the Hill to educate our colleagues and to educate others in the Administration that there is a fundamental difference, that properly conceived investments in research and technology do have a rapidly deflationary effect on an inflated economy.

Additionally, I think we have to be more realistic

in how we view the relationship of federal activities to private sector activities. One way to view that relationship may be to realize that the balance between those two activities is a function of time and risk. In the short term we almost always have to deal with a technology base that is already in existence and, as several of the speakers have already said, the most important thing the federal government can do is to remove the disincentives for technological innovation.

In the midterm, you are dealing with a technology base that may be partially developed or almost developed, but where, within the private sector, even in an optimum environment for risk taking, the risk is just a little bit too high for the attraction of the necessary risk capital.

Now, one would say, and legitimately, all other things being equal, then let's just wait. But all other things are not equal in many instances, and I would draw your attention specifically to our 25-year-plus creation of an energy crisis. Therefore, there are certain technologies that probably would be economic at this time, and would attract risk capital, but do not. They fail to do so for other reasons largely related to adverse federal policies. Through loan guarantees or some other mechanism of that nature, the government will have to encourage the

taking of risks. Various coal gasification technologies and some of the more advanced nuclear technologies are examples of this kind of possible need for federal involvement in a limited way to insure that innovation occurs.

But I think the prime role of the federal government in a positive sense is in those very high-risk future technologies, long-term investments where there clearly is not the availability of risk capital to undertake such investments. The space program in an interesting and unique way was such an investment in high-risk research and technology. There clearly are others, again related to energy. We can look at fusion technology as probably being one of the most important. Breeder technologies may or may not be, again depending on federal policies related to that.

But I think it is important to realize that in almost every area of major national need with respect to technology, it is not a short-term need alone. A whole series of needs spaced differently in time will require different strategies if they are to be satisfied. Although those strategies and tactics have to be implemented simultaneously in most respects, and you can develop a very complex matrix to look at, I do not believe that they are so complex that they cannot be understood and tackled in a very reasonable policy procedure.

Finally, I would suggest, as have some of my colleagues here on the stage, that as a federal government we must take some very positive steps to reduce the disincentives for innovation. A patent policy is one that our hearings in the Banking and Commerce Committees have indicated is a major issue. A uniform patent policy that puts the burden of proof for licensing on the federal government rather than on the private sector is something, I think, that we definitely need. We will be taking steps in the 96th Congress to try to get such a policy.

Regulation and tax policies have already been discussed.

Basic research must be encouraged. There is a very direct link, although a long-term one, between the health of our basic research community and what will eventually become invention or innovation. The one that I have been most concerned about in the 95th Congress, other than the general funding levels emphasis for basic research, was the science policy questions raised by the attempt, which almost certainly will be repeated next year, to regulate at the federal level the basic research of recombinant DNA. There we can see a direct link between very fundamental genetic research and inventions and innovation that will provide a tremendous increase in our ability to produce certain drugs and innovative props, and so forth.

So we must, as a federal government, develop a climate for basic research, but not exclusively within the federal government. Certainly we are far too limited in the investment of the private sector in basic research; but then again, we have heard the reasons why that is probably so.

Steady research and technology policies are a very important role that the federal government can play in high-risk areas. I think all those who are associated with the aircraft industry remember the NACA days where there was a steady flow from government laboratories in cooperation with industry and academia of innovative ideas related to that industry.

Finally, I do believe that we have to recognize opportunities that are offered to us by the attitudes of young men and women in this country who want to do things. If we miss those opportunities, then we are going to miss tremendous opportunities to expand our technology base from which we can do many other things. The space program, again, is an example where young men and women in this country wanted to do something and that opportunity was recognized, and we did it. I would submit that that is still a vast area of opportunity for technological innovation that will have direct applications to us here on earth. As I travel around the country I hear of other areas. Solar energy and fusion are ones that clearly young men and women

are extremely excited about, and they are areas in which we can establish goals that will expand our technology base.

STATEMENT OF ELMER STAATS
COMPTROLLER GENERAL
OF THE UNITED STATES

First of all, I would like to pay tribute to the National Academy of Sciences for its leadership in various fields of science and technology over many years, and to Philip Handler in particular for his leadership of the Academy. My first association with the Academy now goes back more than thirty years, and I think we owe the Academy a great vote of thanks for its work over this many years.

Productivity growth is one of the few economic solutions which benefits all segments of society. Higher productivity enables workers to take home paychecks that do more than offset price rises. So I would like to address my remarks on technological innovation in the U.S. economy primarily to the subject of productivity.

Productivity increases enable the businessman to be more competitive at lower prices, compete more effectively in international markets, helping out the lagging U.S. trade situation. Productivity is the one thing that can keep prices down and the nation's standard of living up.

Productivity gains, however, have averaged only 1.6 percent during the last decade, a discouragingly low figure compared to the 3.2 percent average for the first two decades in the postwar period, compared to the 5 and 6 percent figures of our major trading partners. Three-fourths of the long-term expansion of the economy has been directly attributable to increased productivity. The slowing of productivity growth in the past ten years, however, has resulted in slowing economic growth. If productivity over the last ten years had increased at the same 3.2 percent annual rate of growth of the two previous decades, then output per hour would have been 11 percent higher in 1977. The difference would have meant more than a $100 billion increase in terms of real gross national product at the 1977 employment level.

In attempting to explain the slowdown of productivity advance in the past decade and project to the future, economists tend to concentrate on the four measurable factors: slowdown in the growth of capital stocks per worker, increasing proportions of inexperienced employees, changes in the industrial composition of employment, and declines in research and development.

The greatest hope for increasing the rate of productivity growth lies in advances in technological

innovations resulting chiefly from organized research and development and by increasing the growth in productive capital to keep pace with the growth of the labor force. There has been a failure to recognize that productivity growth is not only affected by the efficiency of labor, but also comes about by incorporating new and more advanced technologies, such as computer-aided design, into new business capital.

Growth of capital investment, which has lagged behind historical rates in the current economic recovery, and increased outlays for research and development are critical both absolutely and in relation to the growth of the labor force.

A particular point of concern has been the relative decline in research and development outlays over the past decade, which will have an adverse effect on the rate of productivity growth in the years ahead. For example, total R&D spending in 1977 is estimated by the National Science Foundation at 2.2 percent of the GNP, compared to 3 percent in 1964. The United States spends over half of its research dollars in defense efforts, while the bulk of expenditures by other major industrial nations with better productivity records have been in nondefense areas.

In 1975 private industry employed 5 percent

fewer scientists and engineers than it did in 1970. And the overall U.S. patent balance declined almost 47 percent from 1966 to 1975. Because of the importance of technological innovation to productivity and our overall economy, these indicators are distressing. Research evidence developed by the National Science Foundation has concluded that the contribution of research and development to economic growth and productivity is positive, significant and high.

According to the 1977 Commerce Department report, technological innovation was responsible for 45 percent of the nation's economic growth from 1929 to 1969. When high and low technology industries are compared, high technology firms have productivity rates twice as high, real growth rates three times as great, one-sixth of the annual price increases, and nine times the employment growth. The same kind of favorable ratio prevails in terms of international trade. The trade balance for research and development intensive manufactured products has been generally rising through the period 1960 to 1976, and is now over $28 billion. The trade balance for non-research and development intensive products is down from a break-even level in 1960 to a $16 billion deficit. Clearly, the technology intensive industries are important in maintaining an overall favorable trade balance.

While these trends show the importance of high technology industries to the economy, their growth has been reduced drastically. As recently as 1968, 300 to 400 high technology industries were founded. But in 1976 the number was zero.

The impact from technological innovation on jobs, sales and tax benefits was pointed out recently by Senator Gaylord Nelson of Wisconsin. He pointed out that a study by MIT of five technology intensive companies showed that over a five-year period jobs grew at a compounded annual rate of 41 percent. Sales grew at the rate of 42 percent, and corporate taxes paid to the treasury grew at 34 percent annually. Last year these five companies had combined annual sales of almost $2 billion, and employed over 67,000 people.

Now, this is encouraging, but to meet the national policy goal of full employment, the U.S. requires technological innovation on a scale that was not achieved for over a decade. Since 1955 the number of people reaching working age has been increasing at an accelerated rate, and at present nearly twice as many new jobs must be created each year as were needed some 20 years ago. Without the underlying scientific understanding and primary technological developments the countless applications would not have come. A single, basic technological change such as a

transistor or the integrated circuit provides thousands of opportunities for application to computers and consumer electronics.

I would like to point up some of the things that it seems to me that the federal government can do in this situation. It seems to me that there are about ten different things that could be a matter of priority for the federal government.

1. To develop periodic needs assessment to determine the nature and extent of public and private sector productivity problems.

2. To act as a facilitator in bringing together various groups on neutral ground to discuss widespread industry productivity problems.

3. To operate a productivity clearinghouse, to provide national and international data and knowledge on various aspects of productivity to all sectors of the economy. Particularly we need to provide private industry with more knowledge as to developments in foreign countries which may have applicability to the United States, or which may impact on our competitiveness.

4. To promote a better understanding of all the factors affecting productivity, including human resources, capital, technology, research and development, transformation of knowledge into practical terms, and

the importance of productivity to our national economy.

5. To provide for a periodic joint assessment by the Joint Economic Committee of the Congress, the Council of Economic Advisors to the President, and the Federal Reserve Board of the productivity impact of fiscal, monetary, tax, and regulatory policies on the private sector.

6. To take the lead in developing improved and acceptable measures of productivity. Our current productivity statistics are weak and do not adequately reflect the role which capital investment, improved technological processes and innovation can play in improving productivity. The Bureau of Labor Statistics and the National Academy of Sciences have done good work in this area, but much more needs to be done.

7. To adopt policies which will stimulate additional investments for R&D by the private sector through tax and other incentives, and encourage industry to recognize the importance over the long term for R&D, rather than focusing on investments which will yield high short-term returns. The new tax bill will help, but the question is whether it goes far enough. Extending the investment tax credit specifically to research and development outlays might provide further assistance. Hopefully the domestic policy review of industrial

innovation scheduled to report to the President next year will result in a new cooperative approach to industrial innovation.

8. To provide new and better ways for measuring the costs and benefits of both existing and new regulations, which can impact on productivity. The regulatory analysis review group established by the President to review selected new regulations is a step forward, but the entire regulatory process needs to be subjected to the rigorous discipline of costs and benefits analysis, particularly those regulations which have been designed to deal with health, safety, and the environment.

9. To continue federal labor/management cooperative programs for upgrading the skills of the labor force, with added emphasis to service trades which now make up some 60 percent of the labor force, and which are expected to grow to 75 percent by the end of the century.

10. To accelerate the efforts of the federal government to measure and improve productivity within the federal government itself, to take a strong leadership role in assisting state and local governments to reduce their costs to improve productivity. A recent study estimates that 20 to 30 percent of state and local employment growth between 1967 and 1976 resulted from

low productivity. Underscoring the importance of this point is the fact that state and local governments now employ 80 percent of all government employees in the nation.

I would like to conclude by saying that perhaps one of the best examples that comes to mind with respect to government/industry/private cooperation is in the field of agriculture, where we find that the Department of Agriculture, working with the American farmer over the many years, has created one of the most productive agriculture industries in the world, by developing joint mechanisms for rural development, rural electrification, worldwide marketing and commodity programs, plus a host of others including capital formation, and unquestionably the most effective R&D base and technology distribution channels. The U.S. agriculture not only feeds America, but also a major portion of the free world. In fact, we see this model copied over and over in other nations, which in many instances have expanded the application to their manufacturing base as well. No doubt this has contributed to their more advanced productivity growth rate.

It seems to me, in conclusion, that it is encouraging that we recently have been showing a new interest in the subject of technology innovation. Although technology innovation does not in and of itself provide the

solution, it is a basic ingredient when it is coupled with all of the other factors which bear upon economic growth, and can be vital to the future of this country.

DISCUSSION

NATHAN ROSENBERG, PROFESSOR OF ECONOMICS, STANFORD UNIVERSITY: Let me make a couple of observations and comments, most of them directed at trying to put some of the issues in a wider comparative perspective.

The point was made that the U.S. growth rate is the lowest of any of the industrialized countries of the world. I would like to point out that that has been pretty much true, not just over the last decade, for which I agree there are genuine reasons for concern, but it has been true generally since the end of World War II.

To some extent the slower growth rate of the United States may be more or less inevitable in that World War II had a devastating impact upon the other industrial countries of the world which it did not have upon the United States. Therefore, one of the things we have been observing for the last 25 or 30 years or so, has been a situation where there has been a natural catching up exercise, where the industrial countries that were unable to develop and to expand for very obvious reasons during World War II found a very considerable technological gap, a situation where they were able

to exploit new technologies which were already available from the United States without having actually to develop them. So to some extent this was a process that was almost built into the situation which the world confronted right after the Second World War. I quite agree that the last decade or so presents some additional reasons for being very concerned.

Secondly, the point has been made that R&D expenditures have been declining as a percentage of GNP, and that is certainly true. But I think it might pay to look at the composition of that decline. The fact of the matter is that since the middle to late 1960's the decline has been overwhelmingly in military R&D. In fact, in the civilian sector, if you just look at civilian R&D, and I have some of the comparative figures here, it turns out that we have not had a very substantial lead if you take civilian R&D expressed as a percentage of GNP. We have not had much of a lead for at least a decade now. If you go back to 1967, when our nonmilitary expenditures were 2 percent of GNP, West Germany was 1.8, France was 1.8 also, the United Kingdom was 1.7, Japan was about 1.3. So the decline that we have observed in the last decade or so has been primarily a result of the decline in the military component.

What I find rather more interesting is that in

both Germany and Japan you find that a much higher percentage of the R&D going on is actually financed by industry itself, and not by the federal government. For 1969, for example, the great bulk of all research in Japan and Germany was carried out by private industry -- about 67 percent for Japan, 60 percent for Germany, as compared to only 38 percent for the United States. It seems to me it would be very interesting to find out more than we presently know about the reasons for those differences.

I was rather surprised to find that not more attention was devoted to the fact that if you look not at R&D shares as percent of GNP, but investment as a share of GNP, and compared the United States to the other industrial countries, you find our situation is far inferior. That is to say, Germany and Japan, our major competitors, have been devoting a far higher share of GNP to investment than we have for a very considerable time, and if you recognize, as several of the speakers have noted, that it is not invention which counts, but the actual incorporation of an invention into the productive process, then it is perfectly clear that our competitors have been devoting a very considerably larger share of their overall resources to actually incorporating new innovations into the productive process.

GIAEVER: Does anybody care to respond?

SCHMITT: I would just like to say that I think you also have to further subdivide in what is the civilian R&D going for in this country, and particularly that within the private sector. There has been a tremendous diversion of research and development funding from the higher risk areas to those which are in reponse to federal regulations and other activities.

ROSENBERG: Oh, I quite agree with that.

HANNAY: Your points are well taken. But let me say also that there is still a concern, even after you take that into account. Let me cite one specific example, which is the rate of introduction of new drugs in the United States, which took a precipitous decline with each successive tightening of the FDA requirements, the most significant of which was about 1962. Since that time the rate of introduction in the United States of new drugs, which has nothing to do whatsoever with catching up -- this is not a question of retarded economic development in Western Europe as a result of World War II -- dropped off by a factor of four, and there was no change in Western Europe.

The result is that many new drugs are being introduced in Western Europe now, quite a long time before they come in in the United States. This is strictly a matter of the regulatory climate.

JAMES HILLIER, EXECUTIVE VICE PRESIDENT AND SENIOR SCIENTIST, RETIRED, RCA CORPORATION: I have just heard a great deal about incentives and disincentives, and I agreed with almost everything I heard. However, they always lead to the concept of profits, and I am not sure that everybody in Washington is in favor of profits. In some work I have been doing recently, I came across a new approach that perhaps gets around this problem. It involves the concept of the "recycling time" of risk capital for entrepreneurial types of investments, particularly that put up by individual investors.

Let me explain. This is a matter of simply calculating what inflation rates, stock market P and E's, individual capital gains taxes, and corporate tax rates have done to entrepreneurial investments. It involves no judgment. If you invested in a standard innovation, say, in the mid-sixties, you could expect to get back your purchasing power so that you could recycle it into another innovation in about seven to nine years. For exactly the same innovation under today's conditions, it takes fourteen to fifteen years to recoup the original purchasing power. This means that we have to use twice as many constant dollars, twice as much purchasing power to achieve the same number of innovations today as it would have taken fifteen years ago. This has nothing to do with profits or incentives.

AARON GELLMAN, PRESIDENT, GELLMAN RESEARCH ASSOCIATES: I would like to make two quick observations, and then ask a question of Mr. Landau and any other panelists who care to respond.

Not all innovation is beneficial and desirable, as I think Senator Schmitt pointed out, and I think we need to exercise caution in recognizing that just because we are trying something new -- if I may paraphrase his classy and classic definition of innovation -- just because there is something to be tried anew does not make it beneficial or desirable in either a social or a commercial sense.

For example, there is a great deal of innovation that does more harm than good per se, I think. Those kinds of innovations we are not considering at this time. However, we should recognize in any discussion about innovation that there is no automatic guarantee that innovation will result in greater benefits than cost, however defined, public and private.

In addition we ought to recognize clearly that we suffer grievous harm from a lack of data, lack of insights, lack of information about the process we call innovation so glibly now. We don't have anything like the amount or quality of data that we could have if we devoted the resources for acquiring relevant data.

One of the reasons for this is that many of the people who sponsor the gathering of data and information about the process of innovation have had too little to do with the process, and therefore do not know relevant data when they see it. In other terms, they do not know how to define relevance so that the data that is gathered under their aegis and sponsorship is indeed what we need.

I hope that there can be something done about this. Along with others who are interested in the process of innovation, the kind of data that I yearn for, for example, would give us some insights into the propensity to innovate generally, some general theories about innovative propensities, about the propensity of the United States to innovate in any given period of time or through time, the propensities of different firms and industries to innovate or not to innovate.

I think also we need to develop measures of innovative performance for our country and for industries that make up our industrial sector. We need to develop these measures of innovative performance both in absolute and relative terms.

Mr. Landau observed that entrepreneurship was important, and I certainly agree with that. Entrepreneurship is what makes it happen. An invention standing alone is the sound of one hand clapping, and we need to convert

the technological possibilities that grow out of R&D into innovations which themselves generate employment, improved distribution of income, and all the other good things that we could all agree upon.

But one of the things that Mr. Landau stressed was entrepreneurship in the private sector. Yet we see an increasing proportion of GNP related to entrepreneurship in public enterprises, and it seems to me one of the things that we ought to do is to try to gain the knowledge, the wisdom, the insights of private sector entrepreneurs, successful ones, and translate what they have learned into something useful to improve the entrepreneurial performance of public enterprise managers.

I would like Mr. Landau's comments, if he will, on how he might achieve this very difficult task.

LANDAU: I wish I knew. My own experience has been, since I try occasionally in my part-time duties as a professor at the University of Pennsylvania, just like you, to say something about how one goes about being an entrepreneur and an innovator. After I get through I have the sensation that what I said and what the students perceived are two wholly different things, which probably is the reason I don't get paid for teaching. But the fact of the matter is that I have learned from my own experience that unless you have been in the entrepreneurial process one

way or the other, in some part of it, you have a terrible time understanding why it is we all say the things we do.

Our country has one very great advantage over almost every other country, and that is the relatively rapid shifting between the public and the private sector that does take place among people. Some Administrations have more than others, and I am not pointing any fingers. But there are indeed considerable recycles of people, and it is probably the best way. Consider some of the entrepreneurs like David Packard, who was in the Defense Department several years ago, or Bill Clements, who was just elected Governor of Texas. They shook things up a bit at the Pentagon. And I suspect that we need more of that.

I would also very much like to see some of the people who are planning to have a government career and go to schools such as the Woodrow Wilson School or the John F. Kennedy School of Government take courses in engineering and technology and economics. I think it would do them a hell of a lot of good.

SCHMITT: I would only comment that there is innovation and there is innovation. As we used to say in geology, there are granites and there are granites.

Some innovation that takes place in this country and within the federal government and in other governmental

entities is the kind of innovation you don't like to see. It is particularly evident in the regulatory environment that is being created. Whether it is consistent with the intent or the word of the laws that give regulatory authority is an issue that would have to be dealt with on a case-by-case basis. But certainly in the area of what are the alternatives to solve a particular problem, frequently the regulators pick the alternative that is high if not the highest in cost for that particular problem.

One of the things that some of us have been talking about within the Congress to maybe put a brake on this kind of innovation is to put the Congress in the business of approving or disapproving those regulations by a systematic process. That is, putting the Congress back into the business of making major law, which they do not do today, defining "major" by some number or series of numbers as it relates to economic impact.

I think it is possible, and that we are going to hear more about this next year. It is an area where, by being innovative legislatively, we can come to grips with the problem of the wrong kind of innovation within government.

JOHN KENDRICK, GEORGE WASHINGTON UNIVERSITY: This question is addressed both to my colleague, Professor Cordes, with respect to his reaction to the theoretical

aspect, and to Senator Schmitt from the viewpoint of political feasibility.

All of the panelists were very much in agreement on the importance of R&D spending, which is a form of investment, and also the more traditional investment in new plants and equipment as carriers of innovation and technological progress.

Now, we all know that the rate of return on investment after tax is considerably lower now in the last two or three years than it was in the mid-sixties, part of which may be due to the anti-inflation policy of the government, which has tended to try to hold back the increase in prices below the increase in costs, but part of which is due to the tax system.

Now, further, various economists think that the U.S. tax system is biased against saving and investment, partly because the income tax drives a wedge between the return realized by the producer and the return realized by the saver. Others say that saving particularly is subject to double taxation, because the income which is either consumed or saved is taxed, but then the return on the investments into which saving flows is also taxed, which reduces the present value of those investments into which saving flows.

The question is: What can we do to reduce the

anti-saving and -investment bias of the U.S. tax system, and to try to hone this in a little more sharply on a particular proposal, which is to exempt saving from the income tax?

This obviously would mean that the income tax would fall on that part of income which is consumed, which would obviously stimulate saving, which is the source of investment, since as all economists agree, saving is equal to investment. But since income is only of value to people when they consume it, when they use it, and the saving has a social purpose, although the individual may get some psychic satisfaction out of the security aspect of saving, still, the consumption tax, which it amounts to, would be progressive and would still fall on the matter of individual consumption, which is very unequal, just as income is. So you don't obviate the progressive nature of the tax by exempting saving.

So I would like reactions on that particular proposal, both from the viewpoint of is this true in theory, is there double taxation, in effect, of saving, and would the exemption of saving help to stimulate investment?

Then, for the Senator, would such a modification of the income tax be feasible? And I might just add one other proposal to mention very quickly, and that is that

others think that we should to go a completely new tax system, which would be neutral. The value-added tax has been put forward as being a neutral system with respect to consumption versus saving, and if anybody wanted to comment on the value-added tax -- I mean, just scrap the whole income tax system, and go to something like that, which is more popular in Europe.

GIAEVER: It is innovative, certainly.

CORDES: Let me first discuss the theoretic issue. We can then consider the constraints imposed by the real world.

The point that the current system of income taxation drives a wedge between the gross rate of return that the market pays to individuals and their "take-home" rate of return would not be challenged by any tax scholar. Moreover, recent empirical work of Professor Michael Boskin of Stanford indicates that this wedge between the before-tax and the after-tax rate of return may indeed have a significant impact on private savings, particularly in the household sector.

However, before I discuss the general merits of moving from an income tax base to a consumption tax base, which is essentially what you are proposing, I would like to emphasize that our current tax system is actually a mixture of the two bases. We have a number of

provisions in the personal income tax, for example, that tax certain forms of savings as they would be taxed under a consumption tax. For example, savings in individual retirement accounts are essentially taxed as they would be under a consumption tax. The saver does not pay tax on the income that is put into the individual retirement account; no taxes are paid on the interest that accrues in the account. The returns to these savings are taxed only when realized into consumption in the saver's retirement years. Clearly then, this form of savings is taxed as it would be under a consumption tax. In addition to this particular example, the numerous tax deferral options provided for investment income have many of the features of a consumption tax.

Unfortunately this is a very real case where having "the best of both worlds" is not desirable. The reason is that by granting preferential tax status to retirement savings and other forms of investments we create incentives based solely on tax considerations for individuals to invest their funds in certain activities. Economists are always uncomfortable when that happens. Indeed, with reference to investments in innovation, it is quite possible that preferential tax treatment of retirement savings may divert some investment funds away from activities that might support innovation. The reason is that such tax preferred

savings tend to flow to financial institutions which have a tendency to invest their funds in specific areas, such as real estate and low-risk investments.

Thus, if moving to a consumption tax would cause all investments to be treated even-handedly by the tax system so that individuals would allocate their savings on the basis of rate of return considerations alone, that would be beneficial for the investment climate as a whole. Thus, even if the shift to a comprehensive consumption tax base did not alter the level of private savings and investment, it would encourage existing savings to be allocated more efficiently among competing investments.

Additionally, if Professor Boskin's results are correct, moving to a consumption tax base would increase total private savings. Whether you believe that such an increase in savings would necessarily stimulate investment depends on how much of a Keynesian you are. In conventional macroeconomics, savings must equal investment ex post. However, it is less certain that increased saving will automatically result in greater investment if there is insufficient investment demand.

Nevertheless, moving to a consumption tax base has important merits. Perhaps the most important is that such a change might remove a number of existing distortions that result when individuals are induced by tax considerations

to invest their funds in particular ways. I think it likely that removal of such distortions would be beneficial for the innovation process as well as for capital formation in general.

SCHMITT: I would definitely say that a major change in our approach to taxation would be very, very difficult in any Congress. However, that is not to say that we might not be able to take some steps with each Congress, and maybe even each session of Congress in the direction that you are suggesting. I agree with everything that has been said about the relationship of a partial consumption tax and a partial income tax; I think it does distort things, and that if we could develop at least a partial but across-the-board consumption tax, we might at least start to see how some of these things would affect innovation and other problems that we have relative to our tax structure.

As an indirect benefit we might find a better retirement security system than social security.

GIAEVER: It is supposed to go broke when I retire, I have heard.

SCHMITT: It is not going to work indefinitely the way it is now structured, because it is not actuarially sound. But by a consumption tax or in a tax structure, we could conceivably develop within the private sector a real

retirement security system that would be actuarially sound. It would take quite a while to transition to that from the present structure, and protect all those with investments now.

I would just finally say that it can be done, I think, but it has to be done slowly and in steps, and of course, you have got to convince Russell Long and a couple of other people on the Hill that it is the right way to go.

CHARLES TAQUEY, RETIRED FOREIGN SERVICE OFFICER: I will ask my question of Senator Schmitt, because it is a question that concerns Congress in the first place.

We have been discussing the reasons for the slowdown in innovation and in productivity in the United States. I have been also an econometrician. I have made some very careful calculations, and I have found a 99.9 percent correlation between the drop in innovation and another phenomenon which has appeared since the late 1960's and which I call, in general, protectionism. Protectionism manifests itself by some of the things already mentioned, such as the difficulty of getting new drugs on the market, the slowness in the development of nuclear plants, and a few others, especially with measures that try to keep away foreign goods in a very ingenious fashion which our

ancestors had not discovered. They had thought of types of quotas, but they had not thought of the wonderful things like the voluntary, paid textile agreement, for instance, these things that are supposed to be voluntary, but which are really the rape of foreign minds.

Well, I just would like to ask Senator Schmitt what he thinks Congress might do next year with respect to that phenomenon, and which I think has a great impact on the question of innovation.

SCHMITT: Well, I agree that there is a correlation between the rise of proposals, and in fact methods of protectionism with respect to imports, and the decline in innovation. I think that there is a cause and effect. However, I don't see how we are going to be able to reverse the protectionist trend until some of the causes for the decline in innovation are removed, because we are continually distorting our economy and our export/import picture by a number of things other than protectionism. With that distortion we create situations around maintaining an industry that may or may not be valuable for national defense, but certainly often is valuable in a local or a regional situation.

Textiles is a good example. If we are going to maintain that as an industry in this country, it may require some protection until we do the other things right.

It is a very, very difficult situation. I am a free trader, but I also recognize that there are distortions to an export/import market, either the ones we create or that somebody else creates, that may require over a short term, hopefully a short term, some degree of protection of a particular industry.

I think the Congress is generally going to move in that direction also if the 95th Congress is any indication.

W. DAVID OSMER, BOEING AEROSPACE COMPANY: I would like to address my question to Senator Schmitt, primarily because it deals with politics, but it also deals with transportation, and I believe that he has spent at least part of his life being transported.

SCHMITT: On Boeing products.

OSMER: Thank you. I was going to make that plug.

SCHMITT: So far, safely.

OSMER: I perceive from various literature and some of the comments that were made here tonight, that there is a great deal of expectation for the current domestic policy review committee on innovation, and I would just like to solicit your opinion, sir, on what I view as a serious shortcoming of that committee.

In light of the fact that the provision of

transportation constitutes nearly 25 percent of the nation's GNP and specifically the aircraft industry is one of the biggest sources of positive trade balance, and that R&D can have a dramatic impact on various transportation modes, why was the Secretary of Transportation not included in the membership of that policy review committee?

SCHMITT: Well, I cannot answer that question. If Frank Press were still here he might be able to. I am equally disappointed in other aspects of the various review committees, interagency and otherwise, that have been created, not only in the representation deficiencies, such as you described -- and I agree with that deficiency -- but also in the lack of interaction with the private sector. There will be claims that there has been interaction because people are in continuous contact with the private sector, who sit on these committees. But I remember the very fruitful days of PSAC and STAC and organizations like that, in which the government came up with a particular proposal and they bounced it off of the experts from the private and academic sectors. That was tremendously valuable interaction.

But I detected very little of that going on today in comparison to the need. Now, there will be examples thrown at me from the floor or elsewhere of

how it is happening. But I will tell you, it is not happening in some very critical areas relative to policy in this Administration, and I think it is a deficiency that they damn well better fix, or they are going to get us in a fix, or they are going to find their policies rejected on the Hill because of inadequate preparation.

FRED DIETRICH, OFFICE OF FEDERAL PROCUREMENT POLICY, OFFICE OF MANAGEMENT AND BUDGET: I rarely get a chance to query senators and a comptroller general. I am usually on the other side of the table.

I would like to ask each of the panelists what he perceives as the really major inhibitor to beneficial technological innovation? Secondly, then, what might be appropriate government initiatives to remove such inhibitors?

STAATS: I will take a run at it. I attempted in my opening remarks to try to define some ten different areas where it seems to me that the government might delineate its role vis-a-vis the private sector. I would hope, incidentally, that the domestic council review, the Baruch-Press review, will help formulate some guidelines here. It doesn't seem to me we have articulated anywhere very well what the role of government should be on the one hand, in providing incentives to the private sector, and on the other hand, removing some of the disincentives.

John Kendrick touched on one of them, which is

in the tax area. But the regulatory area is another one which I think is tremendously important as to how we can provide some way to balance the costs and benefits of regulation with respect to the impact that regulations have on innovation. It would seem to me we have really not done a very good job at all in that area.

I think that there has got to be much more imagination shown than simply stepping up the budget outlays for federal R&D, important as that may be. The big problem is in trying to find some way that you can stimulate the private sector to do more in this field.

I outlined some ten areas, and you could probably add to that list, but at least that was an effort to make a start.

HANNAY: The problem in answering your question is that there is no simple answer that will work for all companies or all industry. It is a very complex issue. All of the things that have been mentioned, the ten items that Elmer Staats mentioned, the things in the regulatory and tax areas, and things that we haven't even mentioned in any detail here tonight, all of them have some importance.

What a particular industry would see as beneficial to its innovation process would be different from what some other industry would see. So the problem is that there isn't a simple answer. You also have to ask which of these are

practical.

SCHMITT: I would agree with that, but I think there are some specific points that if the Administration would get behind there would be some fairly rapid progress. I think that regulatory reform measures such as the one I briefly described -- we now call it Son of 2011, since S2011 was the first number the bill went under. I think it is considerably improved now with its latest introduction. That is a bill by which Congress would get back into the business of reviewing the impact of specific types of regulatory measures that are proposed by the independent as well as the departmental agencies. I think that is absolutely essential, and if the OMB and the President would get behind that kind of a measure, I think you would very rapidly see not only a decrease in unnecessary regulations, but certainly a decrease in the cost and the improvement of the regulations that are necessary. In addition, a review of those that are already on the books would come under such a measure.

The tax measures we have talked about, and there are others that are very simple. They could be taken in a stepwise measure and again would have a tremendous impact. We took a few last year. I think the decrease in the corporate income tax and the capital gains steps are going to help; they are not enough.

HOWARD OSBORN, SCIENCE AND EDUCATION ADMINISTRATION, DEPARTMENT OF AGRICULTURE: I would like to direct my question to Mr. Staats. He referred to some of the needs for defining and getting more data on productivity, but he didn't define productivity itself. It appears to me that we are defining productivity solely in terms of the gross national product, and we have not looked at the costs to society or the benefits to society of some of our -- for instance -- environmental programs.

For instance, in the Department of Agriculture when we look at productivity in terms of production of wheat, and we do not subtract out from that the cost of the soil that is going down the drain, we are calling that production when actually there is a negative aspect to it. On the other hand, if we look at the food processing industry and look at the productivity of the housewife in the home who now can afford to work full time and still put the same dinner on the table that used to, a generation or two ago, take her a full day's work to prepare, we realize that there is a big contribution to productivity there that doesn't show up in any measure of GNP.

I wonder if you could comment on those.

STAATS: I think your point is a correct one. What we are discussing here is an extremely complicated problem of measurement, and the reason that we have followed

the BLS definition, which is labor hours of input in relationship to units of output, has been that we really haven't been able to come up with a much better definition.

Dr. Handler could tell you what the status is of the Academy project. We have been much encouraged by the feedback we have had that maybe this will be a step forward in what we have, in GAO, been describing as total factor productivity, to consider all elements in the productivity picture: capital investment; supervision; coordination; all the things which bear upon this including but in addition to the labor hours of input.

You mentioned the element of quality, and that certainly has to be taken into account. But I don't think it is any particular criticism of anyone that we haven't been able to find a very good definition, because it is an extremely difficult problem of measurement. But that doesn't mean that we can't keep on trying, and I hope we can improve upon it.

SCHMITT: Could I add just one very brief comment in support of the agricultural sector in what they have done? There are some tremendous lessons there. As a matter of fact, for the most part, agricultural innovation has removed the negative impacts of growing crops that used to exist. Certainly in the high plains of New Mexico and in the Rio Grande Valley there aren't very

many negative problems because we have learned how to do it. We have learned how to do it right. We have learned how to produce food in extraordinary quantities with extraordinary efficiency. We just haven't figured out how to get it into the world market for the fair market value. That is another problem that demands innovation.

But I think there are lessons, philosophical and direct lessons, to be learned from the way we did it with respect to the agricultural revolution. We can do it in similar ways with respect to others.

Energy is one area where particularly I think you can apply almost on a one-to-one basis the philosophy of innovation that occurred, for example, through the land grant colleges and the agricultural extension agents, and so forth. There is a very direct application right there.

LOUIS FRIEDMAN, SENATE COMMERCE COMMITTEE: Mr. Staats, several years ago -- I guess it was maybe one or two years ago -- GAO took issue with a study which concluded that federal R&D spending in space had a great positive effect on productivity, and tonight you seem to conclude otherwise. Do you think, as Senator Schmitt stated, that federal spending in high technology areas on R&D will have a large or a significant effect on productivity?

STAATS: I am not sure I got the full import of your question. I believe you are referring perhaps to the statement made with respect to the federal outlays for R&D for defense, and I think he might have added space. Both declined substantially. You have to look behind the gross figures, no question about that.

I think that the question here with respect to the outlays for R&D has to be broken down into its various components. You have your basic research outlays which the present Administration has stepped up some 5 percent last year in real terms. That is important. But then beyond that you get into your applied research field. You have got to break down what it is you are talking about, because it is that area which comes closer to its impact on innovation and new technology.

I don't recall exactly what you are talking to in terms of the GAO criticism. Perhaps I am not recalling it, but that is my general view with respect to the federal government's role in terms of direct support.

LEONARD LEDERMAN, NATIONAL SCIENCE FOUNDATION: A number of speakers, including Mr. Landau particularly, have stated clearly that there is a decline in innovation. As one who has been involved in a number of attempts to measure the rate of innovation, I wonder what they base

those statements on. That is, are there any hard reasons to believe that innovation has gone up, down, or sideways, let's say, over the last decade?

LANDAU: I think that the Science Indicators published in 1977 for 1976 had some pretty good figures on that.

ALBERT A. PLUMMER, CONSULTING ENGINEER: I have gotten the impression over time that an excessive amount of our innovational talent is now being dissipated in the sales wars between competitors who find it more profitable to brainwash the potential consumers in TV and in magazines rather than develop new products or knowledge that is really worthwhile to people.

So my question is: How does R&D expenditure nationwide compare with advertising budget expenditure? Or, for example, how much does the cost of soft drinks in the U.S. compare with the R&D budget?

GIAEVER: There must be an industrialist who would like to answer that question.

LANDAU: Since my advertising budget is very small, I am a very poor fellow to answer that question. I don't think the two are really commensurable. Whether advertising is good or bad is the judgment of each individual company and industry. Just as in R&D they decide to spend more or less, depending on what they

ultimately hope will be the realization in the way of an innovation. They spend money on advertising not gladly, but because they must to move their products. I just don't think we ought to compare the two in any real sense.

ROBERT M. COLTON, NATIONAL SCIENCE FOUNDATION: Over the last few years we have been doing a number of experiments on trying to find ways to stimulate technological innovation through practical demonstrations. The reason I mention this -- I am not going to describe the experiments -- is that there are very few experiments or practical demonstrations of what one might do.

Now, with this thought in mind, I would like to read a very brief excerpt from a study that has been conducted, and this states that, "The committee --" and this is a very special, blue-ribbon committee -- "feels strongly, however, that the National Research Foundation should be charged with the responsibility of studying the process of technological development in industry, and of experimenting with methods of aid to industrial research."

Now, is this the preamble to the domestic policy review, or some statement from the President recently? No. As a matter of fact, this is a blue-ribbon committee report made by the Director of the Office of Scientific

Research and Development, Vannevar Bush, in July, 1945.

Now, my question is this. In the year 2011, 33 years hence, as this is 33 years back, will we have another committee or program group such as we have here discussing what to do about the lag in industrial innovation because previous recommendations weren't examined in any detail?

HANNAY: What he said in 1945 was in a time when conditions were very different. He was certainly a leader in the urging of government to support basic research at universities. He believed that this was essential as a foundation for the innovation process in industry, as it would provide the science needed for that innovation. It was that kind of aid to industry he had in mind, not what we are concerned with here.

COLTON: Sir, I don't mean to interrupt, but that is not what this report was all about. If you examine the titles here, Dr. Bush was talking about assistance to technical clinics for small business enterprise, encouragement for new scientific enterprises, strengthening the patent system, et cetera. I think they were all considering exactly the same argument as you are examining here this evening.

LANDAU: You are quite right. You are speaking about one of the great saints of my old institution. So

how could I disagree with him?

The fact is, you are quite right. There are many previous reports that have been written and recommendations made over the years regarding what is needed for the encouragement of science and technology. Bush was one of the far-seeing ones.

I will refer you to a more recent one, the Charpie Report of the mid-sixties, which is an excellent piece of work. Nobody mentions it anymore. I happened to get a copy of it from Bob Charpie, the last one he had, and I read it through. The thing that struck me as against what there is today is that he is almost silent on the subject of regulation and tax policy.

Now, I asked Bob about that, and he said, "It is very simple. Those problems weren't invented back when I wrote that report." He is right. And this is what I said earlier, that in fact most of the innovations in this country have taken place under a period of really much less taxation and regulation than we have today. It is mainly in the last six or eight years that these burdensome phenomena have appeared. We are all groping for methods that can be found to improve the situation.

I read a letter from Betsy Ancker-Johnson the other day that also commented on this fact. She said: "I have made all this study. Why do you need another one?"

Well, the conditions have changed, even since she made it.

CORDES: I would like to make one brief remark if I may. In my initial comments you may recall that I mentioned one consistent finding that emerges in empirical studies of rates of return to innovation. This finding is that there is a fairly large gap between the return that the innovator captures and the return that accrues to society as a whole. So long as this phenomenon persists and so long as policy makers are unable to deal with it, there always will be concern over the performance of the private market, coupled with consideration of the appropriate government strategies for stimulating investments in innovation. That is, because the full returns to innovation are often not captured by the innovator, I would expect a problem to persist into the future.

SCHMITT: One of the big problems with these kinds of studies is that they convince the studiers, if they are within the government, that they ought to be doing something, and very often they should have been convinced of just the opposite.

RICHARD LEBARON, GENERAL ACCOUNTING OFFICE: I believe the Charpie Report mentioned a topic that a lot of communications firms and computer firms are mentioning lately, namely, that lack of competition in those industries is slowing the rate of innovation. I wonder if

perhaps our economists might comment on the influence of competitive structure on the current rate of innovation.

CORDES: I will only comment briefly, because industrial organization is not one of my academic fields of specialization.

Studies of the determinants of innovation do not reveal a systematic relationship between firm size and intensity of R&D effort. Thus, Schumpeter's view that large firms and indeed, even monopolies, are necessary prerequisites for the generation of important innovations may be questioned.

Certainly the threat of new entrants into markets may be a source of innovation. Thus, if market concentration inhibits entry, market concentration may be seen as inhibiting the development of new innovations. However, generalizations are difficult to make. For example, firms in concentrated industries subject to price regulation may instead compete through the services they offer. One way to compete in terms of services offered is to innovate and create a lot of new products.

My own personal feeling is that there is no simple relationship between market structure and the degree of innovation that is valid in general. It is necessary to examine this relationship on an industry-by-industry basis rather than attempt to make blanket

statements about the impact of firm size and/or market concentration on innovation.

HOWARD MORGAN, NATIONAL BUREAU OF STANDARDS: My question is directed to Mr. Staats but also the other panelists. I would like to put this entire session in perspective by raising this kind of question: What is the real problem we are addressing? Mr. Staats has discussed productivity. The trade balance has been referred to. The question I am asking is: Do we have a problem for which technological innovation is the solution, or do we have scientists who are pushing for full employment for scientists? In other words, are we really concerned with the solution of a problem of demand pull, or are we talking about technology push?

On the issue of productivity, it is well recognized that our rate of productivity is increasing at a decreasing rate. What has the Administration done, and perhaps the Congress? We had a National Commission on Productivity, which was abolished. In its place we had a National Center for Productivity and the Quality of Working Life, which has just recently been abolished. The function has been relegated to some minor agency in the Commerce Department. Do we really see a problem here? If so, what role will technological innovation have in solving it?

STAATS: I think there is a problem, and it seems to me that the problem is not to foster innovation as an end in itself, but as a means to an end, which is to try to increase our competitiveness in the world market, increase our rate of productivity growth. It is like the bottom line of a financial statement for the economy as a whole, and it is the best barometer I know of to tell you how you are doing.

As I think a number of us have emphasized here during the course of the evening, you are not going to improve productivity solely through technology innovation. But technology innovation is an important component of the total picture which is going to hopefully improve our rate of growth in the productivity field.

There are many other elements that play a part here: our tax program, our capital investment program, our federal incentives, federal outlays directly. There are many elements in this. But what seems to be is lacking -- and here again I hope that the domestic council review will help -- is that we don't have a program. We don't really have the components of this program put together in a meaningful way that can result in some legislative action and executive action to this end.

You can search all over the place, and you can't find a program to try to accomplish this objective.

It seems to me what we need to do is to try to emphasize a need to try to put together a total program to improve productivity, including the important component of technology innovation.

SCHMITT: Could I comment on that, because I think that was an important question? I hope it was facetious, because the question really comes down to survival of our particular nation and what it believes in and what it stands for in a very hostile political world, a world in which the environment is becoming increasingly hostile for a number of reasons, and a world in which there is an increasing population competition for the resources of the earth.

It is through technology that this country will survive. It is through technology that the world will survive, but it particularly is an obligation we have to our particular civilization to ensure that we do not fail. It has nothing to do with job creation for engineers or scientists or anybody else. It has to do with survival. And if our economy doesn't survive, we won't survive. If we don't have a technology base from which we can deal from strength with the rest of the world on whatever issue happens to come up internationally, then we won't survive. That is the issue, and that is why it is so fundamental and so critical that we treat it in an

urgent way, but also in a way that takes common sense into account. What has been missing in all of these studies very often -- not all of them, but many of them -- is common sense: standing back and knowing what makes this particular society we have work, how it has worked historically, and how it will work in a rapidly changing environment, but still work.

GELLMAN: In the role of discussant, I want to respond also to Howard Morgan's comment. I don't really think that it is very interesting on a macroeconomic policy level to consider demand pull or supply push, which is it? I think it is on a microeconomic level if we are going to study innovation processes individually, and it is important for that reason alone.

It is well established and we have taken as a given that on balance the process of innovation produces more benefits than it exacts costs, both at the public and private level. I agree with the last remarks that Senator Schmitt made wholeheartedly. But we ought to make it perfectly clear that there are a host of things that government has an obligation to do in conjunction with the promotion of beneficial innovation. What government can and ought to do varies from case to case, which is a point that you were making.

Consider the plight or the opportunities --

depending on what we make of it -- of the Boeing Company and its domestic competitors, Douglas and Lockheed. Here we have a situation where the United States government is funding dramatically and continues properly, I think, to do so, funding in the theory that America will remain preeminent in the field of large commercial aircraft. But we have other elements of government -- prominently, for example, the Antitrust Division of the Justice Department -- that do not seem to understand what the changing technology means in terms of the economic production and engineering production function. Every time someone wants to launch a new type of aircraft in the market in that class of aircraft, one is forced to play "Bet Your Company." They are leading us down the road to giving up predominance even while government acts in a different guise to try to preserve our preeminence.

Mr. Hannay mentioned the drug industry. There are those in the United States who have a fair degree of credibility who will tell you that the U.S. is still -- even after 16 years since Kefauver, since the 1962 drug amendments -- capable of exercising preeminence in the drug field. But we have long since lost predominance. And I don't think we understand the difference between the two.

Most of the members of the Congress appear to

act in such a way that they feel that invention and innovation are synonymous, tht preeminence automatically leads to predominance because the better mousetrap theory works. It doesn't. The more we can communicate this, that it doesn't work automatically, that we have got to make it happen, we have got to make it work, the more we will be better off.

I would just conclude by saying that anybody who can in this day and age -- with what we know about innovation and its benefit-cost relationships and most of its guises -- raise the question as to whether we have a problem and whether innovation is something we should be concerned with on a federal level, on a govermental level, it seems to me, has missed the whole point of this meeting.

GIAEVER: That doesn't really require an answer.

I hope that you have found this discussion stimulating. By watching the hands go up, I am sure you did. I thank you all for coming.

I would also like to thank the panel for their remarks: Joseph Cordes for his comment about the intimate relationship between economy and innovation; Bruce Hannay's clear statement about the problem; Ralph Landau's elegant views as an entrepreneur and the present tax structure; Harrison Schmitt's view on government partici-

pation and regulations, and regulatory laws; and Elmer Staats' ten concrete suggestions about what can be done.

I believe that the discussion did generate more light than heat as Philip Handler hoped in the beginning. Although we have the same problem with us as when we came, I certainly enjoyed this evening, and I hope that you did also.