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Observers have looked at the situation and the flow of technology from the military to the civilian that clearly was occurring in the US in the years after WWII. Primarily in the 1950's, the 1960's in electronics, civil aviation and elsewhere as being the norm. As I read history there is a tendency for the direction of flow to oscillate. In that if one considers what has been going on in military and civilian technology during the middle 1970's and the 1980's there is lots of reason to believe that the net flow was from technology that was first developed by private companies for civilian purposes to the military. And that that flow was significantly greater than the flow from the military to the civilian. Indeed a number of the Dept of Defense programs during the late 1970's, 1980's were expressly aimed at getting american military contractors to pull up their socks regarding their handling of electronics and modern electronic componentry.

I understand that some time ago you were talking to Nathan Rosenberg and he was observing to you about the long long ago importance of the army's interest in weaponry, particularly pistols and rifles and interchangeable parts. On how this, in the early part of the 19th century, lead to the rise of an american machine tool and later on a mass production industry which then spilled over into a wide variety of other areas, sewing machines, ultimately to Henry Ford's mass production technology for automobiles. But then if you ask what was happening during WWII that enabled that massive US military production effort, it was basically the adoption in military production of tanks and ships and other items of the civilian technology that folks like Henry Ford developed.

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ANTONELLO: WHAT HAPPENED AFTER WWII?

WWII was a quite remarkable watershed in the US regarding first of all thinking about the role of the US govt in science and technology. And second of all the importance of science and technology generally. The american scientific community played an enormous role in the development of a number of extremely important technologies of use for the military during the war. And got a very considerable amount of claim for doing that. Their prestige at the end of the war, particularly after the Manhattan project was vastly higher than it had ever been before. Furthermore, the american scientific community found that it could operate with government funds but in many cases with a considerable amount of self direction. What this did was to generate toward the end of the war the development of ideas, proposals and ultimately a manifesto in the form of Vannever Bush's "SCIENCE THE ENDLESS FRONTIER" which proposed a really massive increase in the involvement of the federal govt of the US and public funds in a scientific and technical enterprise.

Now part of that, indeed, went into a continuation of the military design and production and research development capabilities that had been established during the war. But perhaps its most lasting effect was to rationalize and to trigger the major new programs that were launched after the war. Ultimately manifesting themselves in the establishment of the National Science Foundation where the federal govt took over the responsibility for funding academic research in the US. They did that from a pre-war base that was very very small, but by 1960 or so the US had achieved clear world leadership in university research largely on the basis of govt funding of research. A status that it never had at all before the war.

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ANTONELLO: WHAT WERE THE CONSEQUENCES ON THE ECONOMY??

When WWII was coming to an end, a number of economists were forecasting that the US after the war would slip into a depression roughly of the form and substance of the 1930's. That would be the consequence of the very major cutbacks in military spending that were sure to come after the war. Which did come after the war. In fact that didn't happen. What happened was that there was a very major buildup during the war of liquid assets on the part of American households. They had earned a lot and there wasn't that much to spend on. And so rather than being years of depression, the early post-war years were mostly years of boom. That period of time say from 1947 - 48 up until the 1960's indeed were, by historical standards, very rapid growth rate periods for the US. Investment was high, productivity growth was high, employment by and large was high.

You can ask the question, What role did military spending play during this period of time? And that's a tough question. Military expenditure over this period of time, except during the Korean war, was not a major component in total GNP in the US. However, starting in the 1950's military R & D became a significant fraction of total industrial R&D in the US. And the military was doing two things that turned out to have enormous civilian impact. One of them is that they were supporting very broadly a number of areas of technology like electronics, like the development of new materials. And advancing technological understandings and capabilities very broadly, not just narrowly in the form of particular military assistance.

But the second thing that was happening was that the particular technologies that the military was strongly interested in fostering were technologies that very shortly thereafter found a very major role in the civilian economy. Computers which were basically a technology brought into existence on the basis of military demands and military funding. After a short lag, by the middle 1960's, found an enormous civilian market. By the middle 1960's the civilian market had become greater than the military one. Semi conductors and that whole body of technology, again in its early days, despite the fact that it was originally created by Bell Labs, with anticipation that major demand would be in the telephone system. In fact found the greatest demand from the military but again by the middle 1960's or so the bulk of the demand for semi-conductors were coming from the civilian market.

There is the particular episode in which the military brought into place jet aircraft. In particular jet aircraft with a configuration very similar to that of passenger jets. In the early cases it was a tanker which provided the basic technology and funded a considerable amount of the research and development. Indeed it went into the first successful passenger jets, the Boeing 707. Now in my view, this very positive net flow, large positive net flow of technology which was clearly going on during the 50's and the 60's, began to diminish toward the end of the 1960's. And as I suggested

Now most most of the episodes that have been well documented and supported of major flow of military supported technology to the civilian are occurring in 50's and 1960's. After the end of the 1960's, if you read the variety of technological histories, you find less and less in the way of flow from the military to the civilian and more of a flow from civilian technology to the military technology.

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ANTONELLO:GENERAL MOTORS, WESTINGHOUSE

I think there were a number of things going on which caused this diminution of flow. One of them was that the fraction of the military R&D budget that was going into the design of particular large scale weapon systems and the major components that went into those systems increased significantly from the late 1960's into the 1970's. While there are exceptions, that part of the military R&D budget, was the one where you got the smallest spillover into civilian technology. Not strangely because that's the kind of R&D that is very tightly oriented to meet particular kinds of specialized needs. In this case military needs as contrasted with developing general purpose componentry, technological understanding and so on.

A second thing that seems to have been going on during that period of time was a gradual, but in the long run, major change, in the composition of the US defense industry. The US defense industry during the 1950's and the early 1960's, was to a considerable extent, consisting of companies that had large civilian markets as well as catering to military markets. Furthermore, the evidence is that there is a considerable amount of fluidity and mobility within those companies between people who are working on military projects and people who are working on civilian projects. Towards the end of the 60's you began to see a two fold trend. First of all you began to see a larger fraction of military R&D being concentrated in companies that almost exclusively sold to the military as contrasted with selling on both military and civilian markets. You began to get the rise of completely specialized military producers.

And the second thing that happened was that, in the companies that were taking military contracts that also were continuing to sell on a civilian market, you saw more and more in the way of tight separation, between the work that was done on military contracts and the work that was done oriented towards civilian markets. This was induced by a number of considerations. Among other things the accountants and controllers of the dept of defense began to get very tight with respect to accounting requirements and things of that sort. Which forced companies to draw relatively clear lines around their military efforts and to separate them from their civilian efforts. There also was an apparent tightening of secrecy.

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ANTONELLO: Was the Apollo Project military or civilian and what were the effects on the economy?

The Apollo Project was a hybrid but, it looks to me a lot more like a military project than it looks like a typical civilian project. It looks like a military project in that it was an enormous one. Managed from the top down in a way, with rare exceptions, civilian companies are unable to do at least on that scale. It represented an enormous gamble and commitment to achieve a particular objective in a particular way, with an attitude of "damn the torpedos, full speed ahead" which is characteristic of military R&D procurement. And much less characteristic of civilian R&D, at least if companies finance them, where there generally is a considerable amount of checking from time to time whether the project is on course or not. So the structure of the thing was very much in the mold of military R&D projects of that era and of the Manhattan project during WWII.

On the other hand it clearly was a civilian project in that there was much less in the way of secrecy about it. And also the sponsors of the project, NASA and the Congressmen who were supporting and lobbying for it made a considerable amount over the civilian benefits, the spill-over benefits that they argued would come from the project. Until recently at least, that has not been the characteristic of military R&D projects.

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ANTONELLO: WOULD YOU SAY MILITARY SPENDING IS A GOOD INFLUENCE ON THE ECONOMY?

I think that economists have learned enough over the last 45 years or so, so that if it was ever the case that one needed to have a major military program in order to keep aggregate demand up and to keep unemployment from rising, that we have long since left an era where that is so. So I don't think that any of these countries are dependent upon military expenditure as a major source of aggregate demand. And indeed, even in the US, the largest of the capitalist economies, in terms of defense spending if you cut away countries like Israel, for a considerable period of time military spending has been 5, 6% of GNP. Not a very big big percentage. Of course its a much larger percentage in the Soviet Union. That is a problem that they are going to have to deal with. Now regarding the proposition, while total military expenditures were small, that military R&D expenditures accounted for a significant share of the national R&D effort in countries like the US.

My arguement is that while that was an important positive factor in the US during the 1950's, 1960's that there's been very very little benefit from it since the early 1970's or so. And indeed, maybe even a drag on civilian R&D though, the case for that isn't all that clear. Regarding programs in support of basic research. While actually still the military is a non-trivial funder of basic research in the universities I have no doubts that if the military phases out of that other govt agencies and budgets can pick it up. I don't see a very major dimunition in military expenditure which I think is called for on its own merits, as causing any really severe economic transitional problems for the US. It may cause problems for a few companies. Those specialized military producers that I was talking about before.

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ANTONELLO: DO YOU THINK, WITH THE END OF THE COLD WAR, WE WILL SEE A PEACE DIVIDEND OR ECONOMIC RECONVERSION?

I really hope so. I think that all the objective criteria call for a major cutback in military expenditure across a very wide range of activities including a cutback in weapons system Research and Development and procuring, a cutback in the size of the armed forces and bases and things of that sort. What I am worried about is that this country may lack the political leadership and the political resolve to really grab hold of a peace dividnt. Indeed I confess having been surprised that George Bush hasn't grabbed for this issue. It seems to me an issue, that if he would grab hold of it, would enable him to solve very considerable number of the problems that he is facing by cutting down significantly govt expenditures in areas where they are not benefiting the country very much. To free up resources for a lot of other things that he himself has indicated that he wants to do. But to date I have seen no real indications that he has the political will or courage to take the firm leadership that he would have to take with congress in order to do that. Congress of course is an institution in which each and every one of the members has a very strong interest in advocating that certain military

programs not be cutback. Those that are going on in his or her particular region or state. AND the politics of coalitional, congressional voting and negotiation make significant cutbacks in defense expenditures extremely difficult. Unless you have a president who gets way out in front of everybody and says that we have got to, in this instance avoid this parochial, regional, politics and everybody take the cutback and in doing that we'll all benefit enormously from it. I have yet to hear George Bush say anything like that.

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ANTONELLO: DO YOU BELIEVE THAT THE GULF WAR WAS SYMBOLIC OF THE POWER STRUGGLE BETWEEN THOSE WHO WANT RECONVERSION AND THOSE WHO ARE FIGHTING TO MAINTAIN THE MILITARY DEFENSE SYSTEM AS IS?

It's pretty clear that the Gulf War is being used in two ways to resist significant military cutbacks. First of all it is being used as a much signalled example of the fact that while the Soviets may no longer be the threat that we once thought them to be, that none the less there are military threats and contingencies that will pop up all over the world. And its being used second to highlight and dramatize the value of american military technology. And therefor its being used as a vehicle to argue against cutbacks in military R&D procurement and so on. It is absolutely bizaar that the experience in the Gulf War is being used for example, and prominently so, as an arguement for not cutting back on the strategic defense initiative.

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ANTONELLO: WHAT ARE THE CONSEQUENCES OF CONTINUAL MILITARY R&D SPENDING ON THE ECONOMY, SOCIETY, IN THE UNIVERSITY ETC...?

The american military is still is an important force in the funding of university research in the US but, is a small, far smaller and less important force than it was in the years immediately and shortly following WWII. In those early post war years it was the military that took the leap, really, in funding basic research in the univeristies to be sure in a variety of fields of particular interest to it. But these fields were defined quite broadly. And the military agencies funding the universitites for the most part were relatvily sensitive to academic needs for openness in publication. There were a number of secret projects that were exceptions. This is a case where the military jump started the larger scale american system of university research support by govt. But by 1970 or so the role of the military had diminished significantly at universities. I don't have the numbers in front of me. I suspect they're important in certain areas like financing of electrical engineering and certain fields and areas of materials research and so on. However I don't think there would be much difficulty at all, if and when military funds going to universities slow down, for other agencies to pick up on much of this funding. I also don't think that since 1970 or so the military can be regarded as a dominant interest in moulding the nature of university research in the US at all. There's a much much more pluralistic research enterprise than that. And indeed the major funder of university research was the National Institute of Health, as contrasted with Dept of Defense or the National Science foundation. Again, with respect to the evolution of industrial R&D and industrial technologies, while in the 50's and 60's, I think it is fair to say the military needs and the funds to back these up, sometimes in the form of direct R&D funding, sometimes in the form of procurment contracts, which in turn drew civilian R&D to develop the technology to get those contracts, were shaping to a considerable extent what was happening in

those areas of civilian technology, technology more generally. By the 1970's, in a way the military was becoming the tail on the

Since 1970 or so the role of the military in the funding and the stimulating of R&D in the US both, in industry and in the universities, has both diminished relatively and become much more isolated than it had been before as contrasted with being strongly intertwined with the system as a whole. There are a number now of specialized companies or laboratories that do the lion's share of military R&D and do precious little else. They range from govt laboratories like SANDIA to companies that really don't do anything but R&D and producing things for the military like Northrup and North American and organizations like that. Therefor my strong belief would be that if military R&D were to cutback significantly, the bulk of the institutions in the US doing R&D, both industrial R&D and university research, would have very little in the way of impact. The specialized military companies and govt labs, that tailored themselves to military needs would be in deep deep trouble. And there would be a number of university engineering depts particularly electrical engineering departments that at the present time are receiving a certain amount of military work that would also suffer some significant loss of funds. But I suspect the latter could replenish them from other sources.

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ANTONELLO: SOME PEOPLE SAY THAT THE COLD WAR WAS WON BY GERMANY AND JAPAN. IS THAT TRUE??

That's a very interesting proposition. Certainly, if one considers economic growth performance in the post-WWII era, Germany and Japan stand out as among the more advanced industrial nations, among the most successful. But you know France has done very well also. And so has Italy and Switzerland and Sweden. The US and Britain have done relatively poorly. But Britain was in relative economic decline as long ago as the turn of the 20th century. And a lot of what has been experienced in the US, I think reflects a gradual catching up process by the other major industrial nations of the world with the levels that the US had achieved earlier. The US economic growth performance looks miserable in comparison with some of the other countries. But in terms of per capita income and productivity levels, the US continues to stand up pretty well.

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ANTONELLO: IS THE STRENGTH OF THE JAPANESE AND GERMAN ECONOMIES A CREATION OF THE US MEDIA. IS THERE A DIVISION OF LABOR IN TODAY'S WORLD, WHERE JAPAN AND GERMANY PRODUCE FOR THE CONSUMER MARKET AND THE US PRODUCES FOR THE HIGH-TECHNOLOGY MARKET?

In thinking about what has been happening in the world economy since 1960, its very important to understand the very special position the US was in as of 1960. A position that was not sustainable. First of all the US as of 1960 was overwhelmingly the world's leader in mass production industries ranging from steel to automobiles to consumer durables, just a wide range of items. Indeed the US was the world's leader in virtually every industry where there were significant economies of scale and these were associated with heavy mechanization of production. The reason for that was that from the 1880's or 1890's on the US had been overwhelmingly the world's largest market. And during that period of time international trade was sticky. The European countries and Japan were faced with much smaller domestic markets than the US. And world trade was not at that time open enough so they could

compensate for their small market by selling abroad. So the US had these enormous scale advantages in all of these industries.

The second advantage the US had in 1960 stem from the fact that shortly after WWII the US began to make investments in higher education, particularly the training of scientists and engineers and in research and development, both private and public, that far far outstripped any investments that were made anywhere else in the world. So the US, in the post-war era, grabbed hold of the lead in what came to be called the high technology industries of that era. But if you reflect upon that particular episode or that particular time, it should be apparent that both aspects of this US lead had to be transitory. In the first place, largely as a result of US international policies and the GAT, the world was opening up in terms of trade, in terms of foreign investment. For a variety of reasons technology flows among nations were becoming much more easy than had been the case in the inter war period. And as the countries and companies in Europe began to rebuild in the 50's and the 60's they were able to rebuild with an eye toward a significant export market they had not really seen before. And they rebuilt basically along the lines of american technology. If you think about it it is absolutely inconceivable that a little country like Sweden could become a significant producer of motor cars in any period of time prior to the post-war era which was opened up by the general agreement on tariffs and trade. So as the world became a common market the US lost its advantage, its dominant advantage in these heavy industries marked by economies of scale. And other sophisticated countries began to compete very effectively there.

The second major thing that happened was of course that the European nations and Japan looked at the US and what we were doing with our very high level of higher education post secondary education. And all of those countries significantly expanded their tertiary education system. And in particular their production of scientists and engineers. So between 1960 and 1980 you watch the american lead in scientists and engineers as a fraction of the work force, which was enormous over any country in europe in 1960, just dwindle away and dwindle away and dwindle away. So what you got was a group of other countries that now are up to and in many ways surpassing the US levels of investment in science and engineering and research and development. And they are selling on basically the same market as the US, the world wide market. In short, the special advantages that the US had in 1960 are gone.

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ANTONELLO: WHAT IS YOUR IDEA OF PROGRESS?

Progress, particularly economic progress is a very tricky concept. Certainly the measures that economists use to calibrate it are grossly inadequate in a very wide range of ways. However, I would argue, and there is a considerable amount of research on human attitudes and feelings that back this up, that the kind of lifting of living standards of the bulk of the population of the sort that the US achieved between 1910 and 1970 made an enormous amount of difference for many many people. The increases in living standards that have occurred in Europe, largely over the post-war period from middle 1950's up to around 1980's have made an enormous amount of difference to vast numbers of people in terms of all types of dimensions. The improvements in health care, prevention of disease, in duration of life that were achieved over this period of time, the virtual elimination of major pockets of poverty, malnutrition in the advanced countries all of these I think can be counted as major progress. I also suspect that there are severe diminishing turns to this. And once

you achieve the levels of affluence that the US achieved by the late 1960's and the European countries achieved by the 1980's or so that other values and other desires and other needs of human beings may become more and more important. And the price that sometimes, not always, one pays in terms of these other costs may loom larger and larger and therefore you may see a significant tilting of the way these economies work and meaning of what is desirable progress. You certainly are seeing this with respect to the range of environmental issues that's been around for a period of time. Whether these countries have the political resolve to get together and pay the real price that is going to be required to pay in order to deal with them effectively is another matter. I think we don't ought to. There is the issue of the length of the desirable work week and the intensity of the work experience. Where, as you know well, many people outside Japan, are looking to Japan and saying they may produce an enormous amount of automobiles per worker but I don't want to work like that.

So I think there can be a lot of accommodation and rethinking in those dimensions among the rich countries of the world. But on the other hand, we, who are lucky enough to be in the rich countries of the world, have got to recognize that the vast bulk of the world's population has never experienced that spurt of elementary increases in living standards from very wide spread destitution and wide spread malnutrition and ill health that marked Europe and the US at the end of the 19th century and no longer mark us. The Brazils, the Indias's, the China's and the Nigeria's of the world are likely to continue to put an enormous amount of premium on straight forward economic productivity and growth and income growth as measured by economists as they think about the progress they need to achieve. While our values may have changed somewhat because of our affluence we should not fail to recognize that they are behind where we were a hundred years ago in many cases.