NATIONAL ISSUES IN TECHNOLOGY TRANSFER

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A well-accepted definition of technology transfer is "the movement of know how, technique, and technology across organizational boundaries." If you accept this definition, then what is interesting about it is that nobody knows how to do it very well... as a nation, that is. Different nations do different pieces of it better than others. You find the Japanese running around looking at us to see how to do technology transfers from universities to industry, which they do badly. We run around looking at the Japanese to find out how to transfer technology from corporate R&D to manufacturing. And the Europeans are running around looking at both of us.

Why is technology transfer important? What are some of the current issues? What should we do and what shouldn't we do in tech transfer? These are the questions I would like to address my remarks to.

I don't know what the origin of the term technology transfer is, but certainly a milestone in government's concern for tech transfer was the 1914 Smith-Lever Act, which created the Cooperative Extension Service. It was clear that at that time there was a perception of a problem in technology transfer, and there was a significant government response: the creation of the Cooperative Extension Service.

Certainly, one of the next milestones one would have to acknowledge is the 1958 Space Act, mentioned by Don Pearman, which included a clause that said, "provide for the widest practicable and appropriate dissemination of information concerning its activities (NASA's) and the results thereof." This is a clear mandate to do technology transfer. Since then the government's concern for technology transfer has taken several interesting twists and turns, and I want to review them briefly for you.

In the 60s and 70s there was a great deal of concern about getting the most out of the federal investment in R&D. It spawned some specific technology transfer programs in most federal agencies that did R&D. I might mention that the focus in these programs was more on applying that technology to broad social problems than to the commercialization of R&D for reasons that Don mentioned and I will repeat.

During this period, particularly the 60s, federal R&D agencies were regarded as vast storehouses of solutions to social problems as well as technical problems. You may remember the phrase, "if we can go to the moon, then why can't we...", and then you fill in whatever problem you happen to be worried about. The government was assumed to be holding thousands of patents or patentable ideas which, if only we could reach in there and grab these things and commercialize them or apply them to the problems of state...
and local government, would greatly improve things. The prevailing policy, of course, was that government should retain ownership of intellectual property if the taxpayers paid for it. That's one of the obvious reasons that not much was going on in the commercial area. The strategy involved large, passive information dissemination programs. Some of these names you may remember from the distant past: the Defense Documentation Center. Remember that one? NTIS--we still have it. NASA's original notion in technology utilization was a huge database to be accessed by whoever could get a hold of it. ERIC, in education. MEDLARS from the National Institutes of Health.

There were a couple of exceptions. One of them was the Department of Commerce's State Technology Services Program, which was very short lived. Another was the use of technology agents to promote technology transfers to cities, a program sponsored by the National Science Foundation in the 70s. Finally, another program initiated by the NSF in the 70s, the University-Industry Cooperative Research Centers which linked university and industry. I'm going to talk more about them later.

Don Pearman mentioned the legislation since 1980. I'd like to go back a little bit before that to say that there was a gradual opening of government patents to exclusive licensing. NASA, as a matter of fact, has always been able to do it on a case-by-case basis, but proceeded quite cautiously. Then DOE was able to do it on a case-by-case basis, subsequently the universities, then small business. Finally, by 1984 government technology could be licensed exclusively.

The Stevenson-Wydler Act of 1980 required federal R&D agencies to create what were called offices of research and technology applications in the federal laboratories. Specifically, half of one percent of their R&D budgets was to be devoted to tech transfer. Don very nicely went through the subsequent acts which have dramatically opened up the federal laboratories to the possibility and potential for commercial application.

What about the business side? I want to mention this briefly. There was really no concern in industry in the 1960s about what we are calling technology transfer. After all, we were fat and sassy ever since World War II, with limited foreign competition, large R&D budgets in the major companies of America, corporate research budgets which were increasing every year, and very little restriction. We began to get some warning signs in the 1970s--challenges from foreign manufacturers we are all aware of and evidence that the U.S. was losing its "innovativeness." There were some forms that those warning signs took that specifically involved tech transfer. One of them was evidence of an inadequate flow of commercializable knowledge from corporate R&D to business units. A classic case of this is Xerox's Palo Alto Research Center and its failure to commercialize the ideas that were generated there.

Another was the general recognition of the fragmented nature of the innovation process within the firm itself. The metaphor is the 'over the transom' model. The design folks designed, threw it over to the transom development folks, who threw it over to the transom to the manufacturers, and so on. We finally started to realize that this was not the best way to do it. And thirdly, there was an awareness that the NIH, not invented here, syndrome was alive and well in American industry. There was a lack of mechanism in the typical firm to reach out, identify, and access technology and knowledge external to the firm. These were hard lessons to learn, and we are just beginning to do something about it at the firm level.

What were some of the lessons from this period? First, that large-scale passive technology transfer of the kind I mentioned does not work. Secondly, it's misleading to assume that there is a large store of technical solutions to society's problems bottled up in government labs. That is not to say there aren't some very useful technical resources, but in this larger social problem-solving context, I think that myth has been pretty well put to bed. Another lesson was that technology transfer, if it is successful, requires a lot of adaptation. This implies the need for considerable technical expertise and investment in the receiving organization. And finally, as Don mentioned, technology transfer is a body contact sport.
What's the current situation? As I mentioned, there is a general recognition that we and other nations have weaknesses in linking sources of knowledge and solutions to problems to application and/or commercialization, including manufacturing. I would like to share my observations and thoughts on technology transfer in the U.S. in three areas: federal labs to industry, university to industry, and technology transfer to small and medium manufacturers. Let me begin with the federal labs and industry.

There are about 700 federal labs in the US. They spend approximately $25 billion a year in R&D and they employ about 100,000 scientists and engineers. During 1981-90, a ten year period, the total federal license income from the federal labs was $37 million. About $23 million of that (about 2/3) was earned from nonexclusive licenses from an AIDS test kit and a hepatitis B vaccine license. The income to the DOE was about $5.6 million and NASA's income over this period was about $650,000.

Here are some comments from two industry veterans of technology transfer from federal labs to industry. One is from Bob Harrison, who is with GE's aircraft engine division. Bob was charged with searching federal labs and establishing collaborative relationships with them in the field of chemical vapor deposition and ceramic composites. That was a fairly successful effort, by the way. Bob says two things kill a relationship between industry and federal laboratories: money—there's not enough of it, and lawyers—there are too many. You try to establish a program at the bench level, says Bob, exchange technical information, yet nobody thinks about the costs of doing all of this. Recent legislation makes it much easier to work with federal laboratories. The problem is that the company lawyers, not the federal lawyers, are reluctant to accept standard agreements. Now there have been some steps recently to try to create model agreements; we'll see how they work. Another well-known figure to some of you is Jack Simon of General Motors. Jack always likes to cite—I suppose he's kind of like Ross Perot in this sense—but he likes to cite the previous CEO of General Motors who said, "there is nothing in the federal labs we need." It took Jack two or three years of intensive work to find the result that you saw in the clip that Don showed: about 2000 General Motors managers sitting down with 300 scientists and engineers from the federal laboratory in what was called a garage sale at General Motors. There were indeed a bunch of cooperative R&D agreements signed and we will see how those go.

Well, what are the actual situations, problems, and prospects with federal labs and industry? In 1988 some colleagues and I surveyed 250 companies who belong to the Industrial Research Institute. These are large, R&D-intensive companies in the United States. We asked about their experiences working with federal labs, not just with tech transfer. We deliberately did not use the phrase "tech transfer." We investigated interaction ranging all the way from information dissemination, workshops, and seminars, a variety of informal ways in which professionals can interact, all the way to contract research and licensing. We found that the most frequent types of interaction, as you might expect, were the more informal ones: information dissemination, workshops, visits and consultation, with a dramatic falloff in intensity for the others. For instance, about 80% of the companies never used licensing or employee exchange. Sixty percent never engaged in sponsored research, cooperative research or contract research, or even used a lab facility. Among the companies that did interact with federal labs, most reported a positive reaction to interaction of various kinds, with the exception of licensing. The companies that did interact with federal labs expected future payoffs from most of the informal mechanisms: person-to-person contact, information dissemination, laboratory visits, and so on, and least payoff from licensing and industry-supported research. We asked about the factors that accounted for success and failure: person-to-person contact—same old story; middle management support and the clarification of rights to intellectual property. We are repeating this survey right now. What we got in 1988 was basically baseline data. The tech transfer legislation that Don mentioned essentially had not taken effect by that time. It just takes years, as he mentioned, for things to begin to move. They are clearly beginning to move now in a major way, so four years after this we will have data—I hope in about two months—to get some idea across the whole range, not just of licensing and cooperative R&D, but across the whole range of ways in which industry can interact with federal labs.
One of the lessons learned from this research and also learned over this period is that companies regard interactions with less tangible benefits as more likely to promise future payoffs. The visits, information dissemination, technical consultation, and workshops, without the formal stuff, indeed are more likely to have payoffs. As soon as you get lawyers involved, there's less likely to be payoffs.

Second, while the transfer of intellectual property is often thought of as the essence of tech transfer, it seems to me that such a view is myopic. Transfers of intellectual properties are among the few elements of technology transfer that lend themselves to measurement and, thus, they tend to be measured. The concern, therefore, is to measure only those things which can be measured when, in fact, for instance CRADAs, are not an end in themselves; they're a means to an end. Measuring the end itself is much more complex, but more important.

Thirdly, there are limits to federal tech transfer and Don, I think, mentioned many of them; I'll just repeat some of them. Some are cultural. The labs have a mission. The primary mission is not to commercialize technology and presumably it never will be; if it becomes that, then indeed they will be competing with other institutions in this country. There are serious information gaps and requirements that exist, and there is an attitude of suspicion which is slowly being overcome. There are also some significant structural problems: classified research, the U.S. preference concern that Don mentioned, and the fairness of opportunity in access, which he mentioned. There are some others that he didn't mention, including Freedom of Information Act constraints and a product liability. We have yet to see what's going to happen when a jointly-developed product gets commercialized and there's a huge product liability suit. What's the government's responsibility as opposed to industry?

Fourthly, one thing we learned is to visit the labs and get to know the personnel—without it you get nowhere. Recalling Jack Simon again, he says, "more CRADAs get started over cocktails than anything I could ever do."

And finally, limit the role of lawyers. Tech transfer is fundamentally a business activity, not a legal process. Bob Carr, who is at Los Alamos and who did an excellent survey of university and federal lab tech transfer, says lawyers in technology transfer are like the brakes on a car. You wouldn't want a car without brakes, but you wouldn't want brakes to be the only control over the car's movements. So what should be done or not done? It seems to me if the federal labs are to compete in the commercial marketplace of ideas, they are going to have to practice more aggressive marketing and target their efforts carefully, which I think they are already doing. But, I would note, it's really going to cost, and I don't mean just monetary cost, and so to me the concern is to keep your eye on how much cost we are going to bear in order to achieve benefits.

A promising area is the use of intermediaries. There are at least two kinds of intermediaries which look to be very promising in tech transfer for federal laboratories--individuals and organizations. The individuals are called technology ferrets, interestingly enough. They are folks who have been hired by, usually, a consortium of companies interested in accessing a federal laboratory and who have free access to labs. Sometimes these are people who have laboratory and industry experience. They are hired basically to roam the halls of the federal labs, and they not only learn what's in the laboratories but they have in mind the business needs of their clients. The organizational counterpart is of course in organizations, often not for profit. A good example of this is ARCH, the Argonne-Chicago Development Corporation which is associated with the University of Chicago. One of the questions asked earlier was about the role of the universities. Here is a very interesting case where you have Argonne run by the University of Chicago, and ARCH, a not-for-profit research organization acting as an intermediary seeking to move technology not only from the University of Chicago, but also from Argonne into commercial arenas. The CEO of ARCH is the Dean of the Business School at the University of Chicago. Students work on commercialization projects. They have a $9 million seed capital fund to provide capital for start-ups. It turns out that firms prefer to
work with ARCH staff because staff has business backgrounds, rather than with the university or laboratory staff. This helps to bridge the culture gap talked so much about.

Let me move to a very interesting, in many ways overlapping arena, university/industry tech transfer. Industrial funding of university research rose from virtually nothing, $61 million, in 1970 to $485 million in 1985, a three-fold increase in real dollars. The number of university/industry linkages of all kinds is clearly increasing exponentially. There's been a mix of factors, some of which are federal cutbacks in non-defense university research in the early '80s, financial pinches in corporate R&D -- they're starting to look for ways to maximize and lever their dollars, and, finally, competitive pressures from abroad. I'm sure there are other ones, too, but those are some obvious ones. This change has been characterized as a new institutional stance for universities, what you might call active tech transfer. It reaches into the university research laboratory searching for commercializable new applications, and then seeks to develop the product or process with an associated business entity. These universities are aggressively encouraging faculty to seek patents, to undertake more patentable research, seek to license patents assigned to them, and enter into more equity agreements with firms wishing to commercialize university research. In 1982, when we were just beginning in this active role, Harvard President Bok observed as other universities, but not Harvard, were beginning to enter into such relationships, "all in all, the financial advantages to the university appear more speculative than heretofore supposed, while the dangers to academic science from participating in these ventures seem real and severe." That policy lasted just about five years. In 1988 Harvard announced a reversal. It would raise money for investments aimed at bringing faculty members' research to the marketplace, and making a profit for the school. Harvard would raise $30 million from six to eight institutional investors in order to form a series of limited partnerships. These would review research projects by medical school faculty and identify marketable developments, and so on. This is a common picture for major research universities.

How effective, currently, are patenting and licensing operations at universities? Well, there's a survey recently of 89 research universities that counted 844 patents obtained by the universities during the period 1986-89, and about 500 licenses were granted which brought in $11 million. Stanford reports gross incomes from royalties $9 million in 1987-88; University of California, $5.4 million during the same period; Wisconsin, $5 million; MIT, $5 million. Is that a lot or a little? Has it proven cost effective? Are these universities typical? It's really too early to tell, but we do have some useful data from studies of the interaction between universities and industry which I think are going to place some perspective, if nothing else, on the promise in this area.

This draws upon 15 years of experience with the program that I mentioned before, the National Science Foundation's University/Industry Cooperative Research Programs. There are now about 50 of these, more than half of which are self-supporting. Georgia Tech has a Materials Handling Research Center, and it's fairly typical. Typically it's 12 to 15 corporate sponsors who kick in $20,000 to $50,000 a year to have a say in what research is done, and immediate access to students and faculty. The government role is $250,000-600,000 over five years with declining support so that at the end of that period the Centers are on their own. This has really been a tremendous success story. There have been some very careful evaluations done of this program. Some of the results are the following:

Industry and university agree that the most important goal for their center is expansion of general knowledge, and the least important goal is the development of patentable and commercializable products. The major effect on company research has been new products stimulated by recent research, with companies belonging to the first eight centers investing an additional $4 million. This is a good measure of outcome. An additional $4 million, about $1/2 million dollars per center, is invested in their own labs in new projects. This indicates that university research does not generate new technology in any direct sense. It generates technological opportunities. This is supported by a recent General Accounting Office survey of member companies of the Engineering Research
Centers, which again many of you may be aware of because they're at your campus. Of the fifty reasons that ERC industry participants listed for becoming part of an ERC, the opportunity to develop patentable products was the least-stated reason. Only 8% rated it extremely important or very important. Eighty-nine percent cited the match between research at an ERC and the firm's interest as being important or very important.

Monsanto, which is one of the pioneers in large-scale connections with universities at Washington University, notes that after two or three years of experience with a cooperative program, the questions that they asked in trying to determine whether it pays off are:

- Did it cause you to do something different?
- Did it make a change in your research programs?
- Did it change corporate thinking about which science and technology areas are worth pursuing and which are not?
- Did it lead to new projects and goals?

Notice there is nothing in here about a new product.

What have we learned? One-on-one interactions are the most effective means for sharing knowledge about problems and solutions. We keep hearing that, don't we? Transferring research results is only one aspect of a broader network of knowledge exchanges. Fears that patent rights delay publications and loss of confidentiality generally have not materialized, partly because they receive attention continually and partly because truly proprietary R&D tends not to be supported under these university/industry centers.

What do we do or not do? It seems to me in the case of the federal labs we need to be aware of overblown expectations and misplaced focus on the value of what is being transferred. Universities need particularly to pay attention, it seems to me, to the ratio of the financial benefits to the costs of engaging in active or aggressive transfer. There may be some more serious costs to this aggressive stance. Irwin Feller from Penn State has written thoughtfully on this, and I'll simply draw on his thinking before I move to my third and final arena.

Irwin says that university movement toward direct participation in the commercialization of faculty research runs counter to a preponderant set of findings which suggest notable peaks amidst a vaster plain; that is, Stanford, U.C., Berkeley, Wisconsin, and MIT may be the peaks and there may be a very large plain; That is concern for the privatization of technological knowledge. The diversion of faculty findings to specific firms results, Irwin argues, in lower rather than higher rates of technological innovation because of the limitation of information flows that were previously public. Industry itself expresses concern that the universities may be being diverted from what industry regards as their primary and most useful role when they seek to develop specific products. These ventures serve to shift academic researchers from the social roles in which they are most efficient as suppliers of a collective good, namely scientific and technological knowledge available to everyone.

I have a third and final area that I mentioned, the transfer of technology to small and medium manufacturers. Let me begin with some specifics on the role of manufacturing in the economy. Manufacturing employs about 20 million people in this country which is 18% of the labor force. Manufacturing contributes about 22% to our gross national product. Small and medium manufacturers, those with 500 or fewer employees, employ 12 million people and contribute half of all manufacturing's value added to the economy. So, small and medium manufacturers are extremely important, not just financially, but they are, in many cases, suppliers to the large manufacturers. We have a serious problem in manufacturing in this country, and it's more serious in the small
and medium ones than it is in the large ones. In this country, large manufacturers are more likely to adopt new process technologies than smaller ones. Small ones also lag in adoption rates compared with countries like Japan, for equivalent-sized companies. In other words, for whatever reasons, our small and medium manufacturers, many of whom are suppliers to large manufacturers, are not using up-to-date technologies. By the way, there are more small manufacturers in Japan than there are in the United States. We tend to think of Japan as a nation of giant conglomerates. That is not, in fact, accurate. There are about 355,000 small manufacturers in the U.S., but there are more than twice as many in Japan.

Assume for the moment that increasing the amount of new technology in small and medium manufacturers is the potential solution to the problem. We know from Joe's talk that is probably not true. But let's assume for the moment that it is. Then it's appropriate to ask how much the U.S. government and industry spend on technology transfer to small and medium manufacturers. The answer is about $80 million. Contrast this with agriculture. Farming employs 3 million people, less than 3% of the labor force and contributes 2% to the GNP. How much do we spend on technology transfer in agriculture? $1.2 billion for the cooperative extension service shared between federal, state, and local governments. If you think there's something wrong with that allocation of funds, I think you're right. Agriculture extension, created and first implemented in the early 1900s, is based on a simple concept. It uses public universities as sources of knowledge and expertise. It's proven extraordinarily successful, maybe too successful. One might argue that agricultural productivity is excessive. We are, after all, paying farmers not to grow at the same time we're transferring technology to get them to grow more -- part of our political system at work. Some of the features that account for the Extension Service's success are that it's a research system, and it's oriented toward use rather than production. There is a critical mass of new technology and relevant research. There's a high degree of contact, the body contact sport between farmers, the clients and the research subsystem, and a short social distance between each component. It is extremely labor intensive.

Industrial Extension was conceived about 50 years later, and it's predicated on the concept that the key to industrial development and modernization is the continuing adoption of new technology. What is the government now doing to promote industrial extension? The states are at the forefront of this--that is, at the forefront of an exceedingly small wave, $80 million. Georgia has one of the oldest and largest programs. It was begun in 1960; Maryland also has a quite successful one. There are about 42 programs in 28 states that could loosely be called industrial extension or modernization. Most of them are tiny -- ten or fewer staff. There are 13 state programs that use field agents, and only seven run manufacturing technology extensions that offer direct consultations to firms. Total state spending is about $58 million. The rest is almost entirely federal. The scale of these programs, as you might guess, is inadequate. The Michigan Modernization Service, which was abolished but was really one of the best, would have required 22 years to reach all of the relevant firms in the state of Michigan. It has been estimated that the federal government spends about 1% of its $70 billion R&D budget on technology transfer. Only a fraction of that is devoted to manufacturing, and then only a fraction of that is devoted to small and medium manufacturers. In contrast, Japan has a national network of 170 public centers, modeled ironically on Cooperative Extension Service. Its clients are enterprises with less than 300 employees, and they are supported by a budget of $500 million annually, most of which is state and local money. In the U.S. the 1988 Omnibus Trade and Competitiveness Act changed the title of NBS to the National Institute of Standard and Technology (NIST) and called on NIST to take a greater role in diffusing new modern technology. It charged NIST with providing technical assistance to state government extension programs and to create Manufacturing Technology Centers. FY92 funding for this activity was $16 million. The state technology extension program, which was called for in the legislation, was placed in the budget by NIST every year to the tune of some $2-3 million. Every year OMB has taken it out, and every year the Congress puts it back in. There are now five manufacturing technology centers and two more are about to start up.
Recently, at Georgia Tech, we did a study of what we call the industrial modernization problem. It was undertaken for NIST; they asked us to do some long-term strategic thinking for them. One of the things we asked was, "What is the problem with industrial modernization?" It's analogous to the extremely complex set of issues that Joe raised with regard to manufacturing as a whole, but with some additional twists. At the firm level you have a culture of resistance or fear of change, no relief from the immediate problem of trying to get a product out the door. You don't have time to sit back and think. Lack of a long-term strategy or strategic thinking; it's all reactive rather than proactive. There's a problem of being able to cost-justify new technology. Business infrastructure is weak. These companies, these small manufacturers, have only short-term relationships with their customers; there is a lack of vendor support, weak and inactive trade associations mostly engaged in lobbying, rather than any kind of support, and weak links to other manufacturers in the industry and the region. The social infrastructure -- poor education and training services, economic development programs at the state level tend not to be technology level capable; whatever technology modernization does exist is fragmented and unstable.

At the national level there is a lack of leadership on the importance of manufacturing to the U.S. economy. Historically, we have emphasized R&D in advanced technology. This is not best practice and not, in effect a client-pull/market-pull, rather than technology-push, strategy.

What are some of the lessons that we learned? Successful technology transfer is labor intensive and expensive. Federal efforts to apply the agriculture model to other aspects of the economy such as education, energy, and low tech industries over the past several decades generally have not worked, and that is typically because of a failure to appreciate how expensive and systemic the nature of extension really is. Most small and medium manufacturers can effectively use best practice, off-the-shelf technology, not state-of-the-art technology. Finally, most small manufacturers' problems are not amenable to quick, one-shot tech fixes. They tend to be systemic -- very much analogous to the very complex set of relationships that Joe laid out, and they require a range of services that extend to training, business planning, and cost analysis.

Well, what do you do or not do? We identified four models that might be applied. One is to create an agricultural extension system for manufacturing. If we did this, what we call a full extension model, it would cost somewhere, depending on the assumptions you make, in the area of $800 million under a formula grant system like the Extension Service, using field agents and so on. By the way, that is total funding, not just federal, and all of this assumes cost sharing. A second model would take the research element away and still retain the extension part of one-on-one technical assistance, while the state has a minimal role in R&D. The cost may be $150-400 million.

A third model, one we've labeled the Center-Satellite-Gateway, begins to build on what we now have, which is the Manufacturing Technology Centers as strategically placed federal centers that sit atop a tiered system of secondary and tertiary service providers. I'm running out of time and I won't go into too much detail. The cost range of this, depending on the assumptions, might be $150-600 million.

Finally, a very different kind of approach might be the broker networking approach, which relies almost entirely on information sharing among companies and clients themselves as the primary problem solving mechanism. Here the state's nonprofit trade associations play the brokerage role. The cost would be far less, maybe $15 million under minimum assumptions to as much as $270 million.

Well, what should we do or not do? We ought to resist the technology push argument and insist on need-driven programs of support. We ought to support federal programs to provide significant, stable, yet flexible support to state programs in industrial modernization. I think the modified extension plus some of the network model offers the
most promising approach. We ought to put at least as much federal emphasis on small
and medium manufacturers as we do on technology transfer for federal laboratories. It
would take less than 1/2% of the federal R&D budget to do this very well.

What are some common threads? Common threads that I think are not only
common but a little disturbing to me are these. First, as you look across all three of the
areas that I emphasized, it seems to me what you see is an overdependence on
technology as a solution to problems. My colleague and historian of technology Mel
Kranzberg is fond of saying, "Technology is the answer. Now, what was the question."

There is an emphasis on tangible, measurable payoffs rather than what eludes easy
measurement and valuing, but in the long run offers greater net payoff. I think this is far
more than the old joke about the drunk who looks futilely under the lamp post for his
keys when he didn't lose them there, but he's looking there because the light is better
under the lamp post. Instead, I think the proper analogy is the kind of thinking that led
us as a nation to ignore the value of product quality in our system of national accounts,
because it is hard to measure quality.

Here are a couple of final words on technology transfer from federal labs and the
universities. The more goals to which an organization aspires, the fewer resources it can
devote to attaining each one, the more difficult it becomes to manage strategically, and
the less likely it is that the core reason for the institute's creation, its unique raison d'etre,
will be well served.

As final words on technology transfer to small and medium manufacturers, I hope
that as a nation we devote sufficient resources to industrial extension and modernization
so that someday a future Jim Hightower will write a manufacturing equivalent to the
book, *Hard Tomatoes, Hard Times*. Maybe it will be titled, "What to Do with Your Excess
Productivity." I don't think that is going to happen unless we decide as a nation to divert
our resources toward where the problems are, in an appropriate balance.

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