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I am delighted to have this opportunity to address this joint meeting of the Minnesota and North Dakota Academies of Science. Today I will be discussing the important issue of research and development funding in the Midwest—especially as it may affect economic growth in the region. I will paint a picture of what I think are very alarming trends in federal and industrial R&D funding to companies and universities in the Midwest. I'll also describe one of the options we in the Midwest have to counteract these patterns.

Introduction

Although it is difficult to prove, we have come to accept as an article of modern faith that investments in science and technology are a necessary precursor to enterprise and job creation. We have come to believe that, without new technology, our companies cannot compete in global markets. Without adequate profits, the prospects for new jobs, government services and social amenities all decline.

The United States is certainly not the only country that has accepted and acted on this premise. In fact, recent data suggest that some other countries are taking this idea much more seriously than we are. For example, in Figure 1, you can see the recent patterns of R&D investments of some of our leading international competitors (1). In nearly every article you read these days about our overwhelming trade deficits, there is further confirmation that Japan as well as other trading partners are using investments in science and technology—especially applied R&D—as an element of international competitiveness.

In response to the increasing competitiveness in technology development, the governors of nine Midwestern states founded the Midwest Technology Development Institute (MTDI) in 1985. MTDI, a nonprofit corporation, was formed to strengthen economic competitiveness and create more jobs in the Midwest through technology development and transfer. As I'll describe later, MTDI is forming a series of cooperative research partnerships with participation by the region's major industrial corporations and research universities.

As we evaluated where the Midwest stands *vis a vis* other regions, we conducted a strategic assessment of R&D funding patterns. It is the remarkable findings from this analysis that I want to present today.

Trends in R&D Funding

First, the share of federal R&D funding captured by companies and universities in the Midwest has dropped dramatically in the last five years, especially as compared with the share captured by companies and universities in coastal states. The coastal states are defined for this discussion as the 15 Atlantic coast states plus California. The Midwestern states are those 12 states which are members of the Midwest Governors Conference.

In Figure 2, the 10-year growth curves for total federal R&D obligations to these two groups of states are shown. These data were taken directly from National Science Foundation reports (2,3). This illustration clearly shows that the growth rates in the 1975-1980 period were different from the growth rates in the 1980-1985 period. In fact, the compounded annual growth rates were dramatically different in the two time periods. The growth rate for federal R&D support to Midwestern companies and universities dropped from 14% to 4.8%, even as the growth rate for federal support to their coastal counterparts grew from 7% to 12%.

The effect of that alarming shift can be expressed in very practical terms:

- From 1975-1980, total federal R&D support, on an annual basis, grew by an increment of $10 billion per year. By the end of that period, the Midwest was capturing an additional $2 billion per year.
- From 1980-1985, however, total federal R&D support grew by an increment of $20 billion per year, with the Midwest capturing only an additional $1 billion per year by the end of the period.

Second, federal R&D obligations to Midwestern companies have lagged dramatically behind those to companies in the coastal states over the last five years. In Figure 3, the growth curves for federal R&D obligations to industry are shown (4,5).

- From 1975-80, federal R&D support to Midwestern companies grew more than 19% per year, well above the national average of 9% and the coastal state average of 6.5%.
- From 1980-1985, however, federal R&D support to companies in coastal states grew much faster (12.5%) while the growth of such support to Midwestern

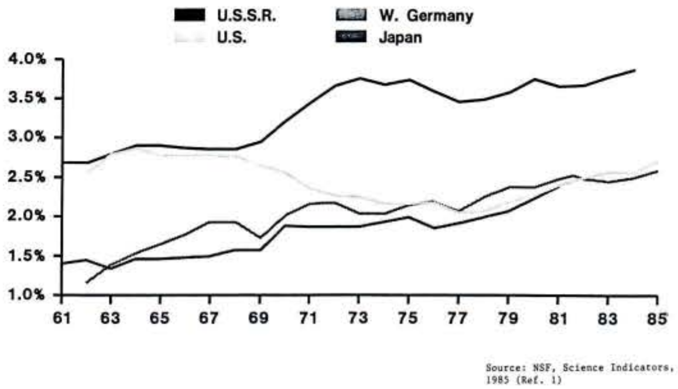

Figure 1. R&D spending by country as a percent of gross national product, 1961-85 (Ref. 1).

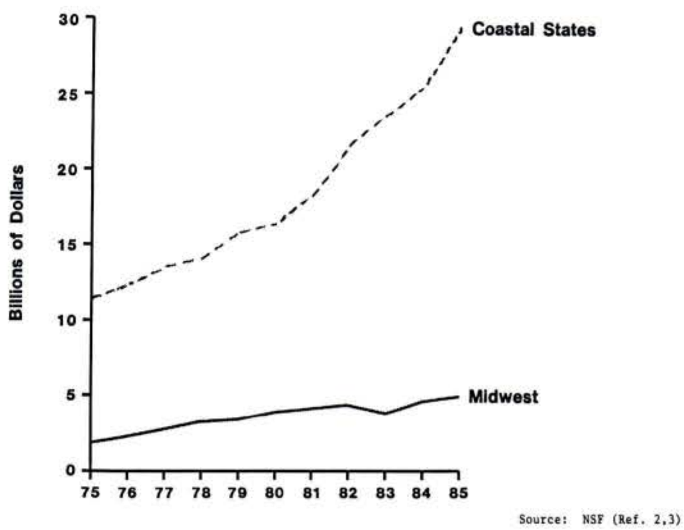

Figure 2. Ten-year growth curves for total R&D obligations to coastal states and Midwestern states (Ref. 2,3).

industries dropped to only 4.8% per year, a dramatic difference of 8% per year.

Third, federal R&D obligations to Midwestern colleges and universities have also lagged considerably behind those to colleges and universities in coastal states over the last five years (6,7). In Figure 4, the growth curves for federal R&D obligations to colleges and universities are presented. A comparison of the growth rates in the same time periods indicates that:

- From 1975-1980, federal R&D support to both Midwestern and coastal universities grew at about the national average of 11% per year.
- From 1980-1985, federal R&D support to the coastal universities grew at a more sluggish 9.5% per year. Federal support to Midwestern universities, however, grew at only 7.5% per year—a difference of 2% compounded annually.

If federal support to Midwestern universities had also grown at 9.5% per year, then they would have received $320 million more over the 5-year period—an amount well worth fighting for.

Fourth, industrial R&D support to Midwestern colleges and universities has also lagged comparable support to coastal colleges and universities. For the 1980-1985 period, industrial support to coastal universities grew at 17.5% per year while industrial support to Midwestern universities grew at 14.2% per year—a difference of more than 3% per year (8,9).

"Explanations" for the Trends

Because of some of the obvious differences between the Midwest and the coastal states, it is easy to jump to the conclusion that there are logical explanations for the disparities in the federal and industrial R&D funding patterns. In fact, some of the "explanations" offered for such marked changes in these funding patterns include:

- The coastal states have many more people than the Midwest.
- The coastal states have many more scientists and engineers than the Midwest.
- The coastal states have more graduate students in science and engineering than the Midwest.
- The coastal states pay more taxes than the Midwest.

Let's analyze these explanations individually.

Population

It's true that the 16 coastal states have 42% of the U.S. population while the Midwest has only 25% (10). But that doesn't explain why the federal government spends about $340 per person for R&D in the coastal states and less than $80 per person in the Midwest (11). That means that the coastal states receive more than four times more federal R&D support per capita than the Midwest.

Scientists and Engineers

It's also true that the coastal states have 46% of the nation's scientists and engineers while the Midwest only has 20% (12). But that doesn't explain why the federal goverment spends more than $20,000 per scientist or engineer in the coastal states and only $5,700 per scientist or engineer in the Midwest (13). The coastal region receives 3.5 times more federal R&D support per scientist and engineer than the Midwest.

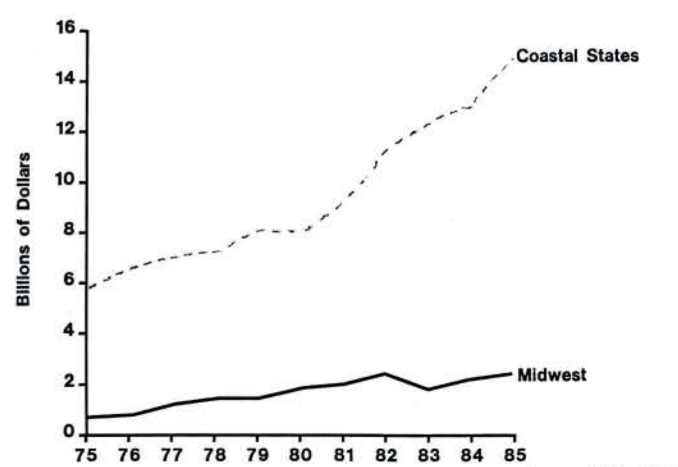

Figure 3. Ten-year growth curves for federal R&D obligations to industry in coastal states and in Midwestern states (Ref. 4,5).

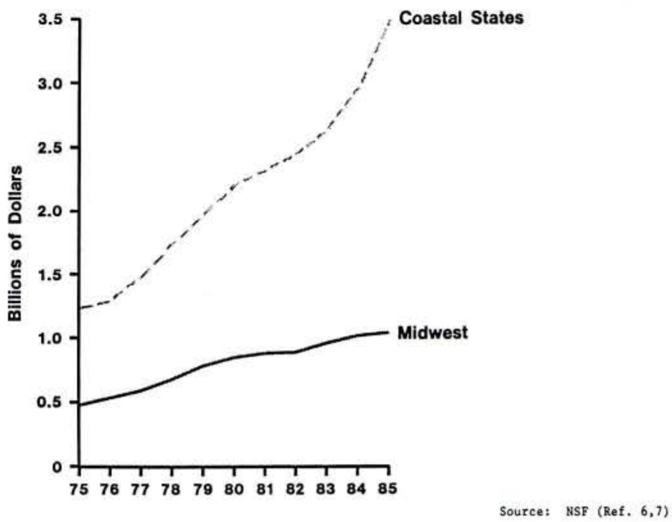

Figure 4. Ten-year growth curves for federal R&D obligations to college and universities in coastal states and in Midwestern states (Ref. 6,7).

University Graduate Students

Again it's true that the coastal states have 45% of the science and engineering (S&E) graduate students while the Midwest has 24% of those students (14). But that doesn't explain why the federal investment in R&D at colleges and universities in the coastal states is more than $20,000 per S&E graduate student and only $13,000 per S&E graduate student in the Midwest (15). It means that the coastal region receives nearly 1.6 times more federal R&D support per S&E graduate student than the Midwest does.

Taxes

Finally, taxes. Taxes are supposed to be the ultimate expression of national economic and social policy. It's true that the coastal states paid more taxes ($343 billion) than the Midwest ($196 billion) in 1985 (16). On a percentage basis, citizens in the coastal states paid 46% of the nation's taxes—slightly higher than the 42% of the population which they comprise. Midwesterners paid 26% of the taxes, compared to their 25% share of the population. So there is reasonable equity in the tax burdens.

But how are the taxes spent? On a national basis, about $47 billion or 6.4% of our federal taxes are spent on R&D (17). The coastal states, as noted earlier, receive a disproportionately high share of the federal R&D obligations—their share amounts to 8.5% of their federal taxes. The Midwest, on the other hand, received a disproportionately low share, amounting to only 2.6% of their federal taxes. Here again we find the coastal states receive 3.3 times more federal R&D than the Midwestern states in terms of federal tax dollars returning to the states.

Let's put this on a more meaningful basis. For each $1,000 that the IRS collects from the states, $64 should—if there were an equitable distribution of federal R&D support—come back to the states for R&D. The coastal states receive $85 while the Midwestern states receive only $26. Minnesota receives only $43 for R&D, while North Dakota receives only $29 at this time. In fact, not a single Midwestern state receives anywhere near $64.

By comparison, $1,000 in federal tax revenues from California returns $126 to that state. One thousand dollars collected in Massachusetts returns $152 to that state. Doesn't this indicate that the Midwest is in the backseat as far as federal R&D is concerned?

There are many different ways to show how skewed the allocation of federal R&D dollars has become. If federal R&D obligations are viewed as a form of transfer payments, then the Midwest supplies more than $5 billion to California for R&D and more than $2 billion to the Atlantic coast states (17).

Taking all these factors into consideration, the Midwest's situation is analogous to that of a nineteenth century colony providing the riches to fuel the industrial revolution in the mother country.

Defense R&D Spending

The only part of the federal budget which has grown significantly since 1980 has been the defense budget. Defense R&D expenditures grew at about 9% from 1975-1980 (18). Along with general increases in the Department of Defense (DoD) budget from 1980-1985, the DoD R&D budget grew, during that period, at 15% per year (19). (Figure 5.). By comparison, total federal civilian R&D grew at 9% from 1975-1980 and then shrank at 3% from 1980-1985 (20). Thus, defense R&D growth had been the dominant factor in total federal R&D spending in this decade.

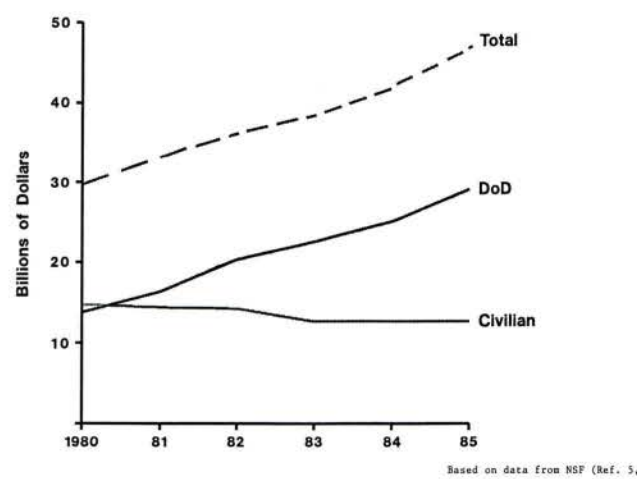

Figure 5. Civilian and Department of Defense (DoD) R&D obligations, 1980-85 (Ref. 5, 19).

With the majority of the defense contractors located in the coastal areas, it is no surprise that the allocation of defense R&D funding has been significantly tilted toward the coastal states. In 1985, 68% of the total federal R&D dollars spent in the coastal states came from DoD. Not surprisingly, California, Massachusetts, and Virginia receive 72, 76, and 80%, respectively, of their federal R&D dollars from DoD. Lagging behind is the Midwest, with only 58% of its federal R&D funds coming from DoD in 1985 (21).

Defense R&D support to universities in the two regions follows similar patterns. In 1985, 20% of the federal R&D support for universities in the coastal states came from DoD, while less than 8% of the federal R&D at Midwestern universities came from that department (22). The only bright spot for the Midwest is that, from 1980-1985, Midwestern universities attracted DoD R&D support at a slightly higher rate than coastal universities, 15% vs. 14% compounded annually (23). But this edge has done little to close the gap.

Effects of R&D Trends on the Midwest

At this point, we should ask if these disparities in R&D funding among the regions make any difference. What have been the effects, if any, of these disparities? What are the likely future effects?

First, let us examine the recent economic performance of the Midwestern region *vis a vis* the coastal region. Since there are no tabulations of gross national product (GNP) for individual states, it is necessary to use other measures of growth if state or regional trends are to be examined. Using income derived from employment and proprietorship as a surrogate for GNP (it accounts for about 64% of GNP), the U.S. economy experienced a real growth of 2.5% per year from the first quarter of 1981 to the end of 1985 (24).

Again using the same data, the economies of the coastal states grew at almost 4% per year during the same period. These 16 states accounted for nearly $163 billion or *70%* of the real growth (1982 dollars) in wage and proprietorship income that occurred nationally during this period. For the sake of comparison, the coastal states contributed only 47% of the GNP during 1981-1985.

The coastal states receiving the greatest advantages in federal R&D support experienced some of the highest economic growth rates in the country. Virginia and Massachusetts were in the five fastest growing states, while Maryland and California were in the top 15.

In contrast, the same measures indicate that the Midwest only grew at 1.2% per year during the same period. The Midwestern states accounted for $29 billion or *only 12%* of the real growth (also 1982 dollars) in wage and proprietorship income—despite the fact that the Midwest contributed 25% of the GNP during 1981-1985. This means that the coastal states grew more than three times faster than the Midwestern states, significantly increasing the gap between the two regions.

It is, of course, too simplistic just to use recent economic performance as a measure of the effect of federal and industrial R&D spending on the different regions. There have obviously been a number of extenuating circumstances which have tended to suppress growth in the Midwest during the past six years:

- The severe recession, starting in 1981, which hit manufacturing, agriculture, and mining preferentially.
- The growing impact of aggressive foreign competition, masked at first by the recession but increasingly obvious as the recession lifted.
- Slow worldwide economic growth which continued to depress demand for commodities (agriculture, mining, oil) and for many manufactured durable goods, which have historically been strong in the Midwest's economy.

Business Week, in a recent cover story, declared that much of the Midwest is in a "deflation belt," stretching from Canada to the Gulf of Mexico (25). This deflation has been brought on, according to *Business Week,* by a downward spiral in raw material prices, falling land values, lower wages and profits, and bankruptcies.

Because of the complexity of the national economy, it is exceedingly difficult to trace the effects of dispersed input such as R&D spending. Such inputs ripple through the economy, with apparently quite different multipliers and with variable time lags. There is a growing body of evidence that increased industrial R&D and increased federal contract R&D do enhance economic development, especially productivity (26). This is not necessarily a new phenomenon; rather the economic analyses have only recently become sophisticated enough to estimate an effect everyone thought was occurring anyway.

There is further evidence that the effects of some R&D investments may be delayed in time (27). For example, federal contract R&D spending seems to stimulate an almost immediate investment of private R&D dollars. With the multiplier effect, strong positive impacts can be seen in local and state economies. On the other hand, the effect of public and private investments leading to technology commercialization may not be seen in the form of increased sales or decreased costs for 5-10 years down the road (28). Interestingly, the positive effect may not show up in the profits or productivity of the company actually doing the R&D, but rather in the performance of the companies which purchase the improved products. This appears to be especially true in the case of manufacturing companies (29).

Of most importance for the Midwest may be the more subtle, less easily quantified effects of federal and industrial R&D investments in colleges and universities. Although it has not yet been proven by economic analyses, the value of investments that build the infrastructure for technology-driven enterprise formation and job creation should not, in my judgment, be underestimated. The markedly lower federal and industrial R&D investments in our Midwestern universities relative to those in coastal universities are putting our universities at a distinct disadvantage in recruiting quality faculty and graduate students, maintaining research equipment and facilities, performing sophisticated cutting edge research, and, in turn, competing for future R&D funds—in other words, a vicious cycle which feeds on itself.

Similarly, fewer R&D dollars going to Midwestern companies means that those companies are in a poorer position to compete for future R&D resources. This situation also means that there is a smaller base of potential entrepreneurs working in our large companies as a precursor to enterprise formation.

Together, these trends mean a smaller number of new company formations, fewer new technology-based jobs, loss of educated, skilled workforce, slower economic growth, and lower state and private investments in educational resources and social amenities. All in all, we are confronted with a diminished capacity to compete, domestically and internationally.

Midwestern Assets

Lest these discouraging words paint too grim a picture of the situation in the Midwestern states, I should state unequivocally that there are many positive aspects about the economy and people of the Midwest. We must remember that this region has had a significant positive impact on overall national growth since it was settled in the mid-1800s. As late as 1984, the region accounted for 29% of the nation's manufacturing workforce and 31% of the value added by the nation's manufactures, while having 25% of the nation's population (30). In 1983 (the last year for which state-by-state statistics were available), the region contributed more than 31% of the nation's exports (31).

It seems that every Midwestern state has received a wide range of rankings in one or another ratings of state business environments. For example, in 1986, the annual Grant Thornton Ranking put South Dakota, Nebraska, and North Dakota in its top five states for manufacturing climates—based largely on the relatively low cost of doing business there, i.e., cheaper wages and low taxes (32). This ranking is, in fact, useful for certain manufacturing firms that have fairly stable markets for low-cost commodity products, heavy capital investment requirements, and relatively low-wage work forces. One indication that this ranking is valid for certain businesses is the relatively favorable trend in manufacturing jobs in those states—especially when compared to national and Midwestern trends.

Granting that the base of manufacturing jobs in those three states is much smaller than in the traditional industrial states, North and South Dakota have led the Midwest in growth in manufacturing employment since the second world war (about 2.5% per year compared to 0.5% nationally) (33). Nebraska's manufacturing employment has grown 1.1% per year over that same period. Since the recession in 1981, both of the Dakotas have experienced much stronger recoveries in manufacturing employment than the nation or other Midwestern states. Nebraska's recovery has equaled the Midwestern pace of recovery but has lagged the national average.

Other recent analyses, which take a different perspective, have put other Midwestern states in a more favorable light. The first of these was sponsored by Ameritrust of Cleveland and performed by SRI International (34). The second was conducted by the Corporation for Enterprise Development in Washington, D.C. (35). These reports argue that rankings such as Grant Thornton's are less suitable for many advanced technology, high innovation firms that have rapidly changing markets, require highly skilled and adaptable work forces, and need to offer an environment which will attract and retain top engineers, scientists, and entrepreneurial managers.

Some of the factors which these reports emphasize as most important are the number of engineering and science Ph.D.s, the percentage of the population with high school and college degrees, the number of patents, business formation rates, investments per production worker, the readiness of local banks to invest money in local companies, and the efforts of state governments to foster the development and spread of new jobs. In other words, such measures give insight into current economic performance, vitality of existing business, capacity for future growth, and policies that foster such growth.

Based on these latter measures, the Great Lakes states generally rank higher than the Plains states. For example, one measure is the ranking of the top graduate schools in arts, sciences, and engineering. As seen in Table 1, universities in the states of Indiana, Illinois, Michigan, Minnesota, and Wisconsin capture eight of the top 30 spots nationwide (36). The states of Michigan and Wisconsin rank near the top nationally in total state and local per capita expenditures for education (37). Illinois, Michigan, and Minnesota rank well above the national average in the number of patents issued per capita (38).

Several of these states have established new programs to foster cooperative industry and university R&D and to provide venture or equity capital to growing firms. Some of these programs have even become models that many of the other states are emulating.

The ironic fact is that all of the rankings have some element of truth. The old cliche "it depends on your perspective" works well here.

A careful review of nearly all rankings reveals one underlying strength which we Midwesterners always tout—intelligent, hard working people. In an age when we are fearful of being outstripped by foreign competitors, it is reassuring that the average ACT scores in all Midwestern states are higher than the national average, with the ACT scores in Iowa, Minnesota, Nebraska, and Wisconsin significantly higher (39). This is further reinforced by the fact that a higher percentage of our youth (16 to 24 years old) are attending four-year colleges and universities than do nationally (40).

Table 1. Leading Graduate Schools in the Arts, Sciences and Engineering (36).

Institution	National Rank
University of Chicago	7
University of Michigan	8
University of Wisconsin-Madison	8
University of Illinois-Urbana	13
University of Minnesota	16
Northwestern University	18
Indiana University	21
Purdue University	25

As a footnote to this section, I should also mention another recent report on Midwestern states. This one was prepared by the Long Term Credit Bank of Japan and is an assessment—a very positive one, I might add—of the business climate in the Great Lakes states for Japanese companies (41). The report points out that the three most important criteria Japanese companies use in setting up operations in America are:

- Proximity to a concentration of industry
- Availability of high-quality workforce
- The local hospitality

To paraphrase slightly, the report concluded that the region generally appears eager to attract industry, had helped companies new to the region to get started, and has also helped transferred employees feel very comfortable. These words could, of course, be applied to the entire Midwest. In all, this is a nice compliment about our people from our most aggressive competitor.

Regaining Competitiveness Through Cooperation

With so many assets, how can the Midwest become more competitive for federal and industrial R&D funding? One approach is now being developed by the Midwest Technology Development Institute (MDTI) to leverage public and private investments to obtain maximum returns: cooperative research, development, and technology transfer. MTDI is currently in the process of establishing three cooperative R&D partnerships—in advanced materials, manufacturing, and agriculture. I will use the *Advanced Ceramics and Composites Partnership* (ACCP) as an example of how Midwestern companies and universities can work together to improve their competitive position (42).

Briefly, advanced ceramics and composites are defined as inorganic nonmetallic materials (oxides, nitrides, carbides) capable of performing critical functional and structural roles under extreme environmental conditions. There are numerous uses for advanced ceramics—in automobile engines, machine tools, superconducting devices, electronic devices, transducers, and bioceramics for bone and tooth replacements.

Current estimates place the high technology ceramics market at $5-6 billion worldwide and $2-2.5 billion in the United States, and growing at respectable rates (8-12% per year) (43). Japan is now the world leader in market share, with 50% or more of many product areas, especially electronic ceramics.

The Midwest has a critical mass of expertise in advanced ceramics and composites. In our universities, we have 12 major academic and research programs in ceramic engineering with an equal number of smaller programs. We produce 39% of the nation's materials science and engineering graduates (44). We also have major university programs in polymer science. In our industries, we have heavy concentrations of current and future users—automotive, machine tool, supercomputers, heavy machinery, and aerospace. Midwestern states have been leading the way in promoting university/industry cooperation.

MTDI is now in the process of forming the partnership involving these industrial and university resources. We have brought together nine distinguished U.S. ceramics experts to advise us on the formation of the partnership. We have documented the capabilities of 24 Midwestern university research programs. We have met with key representatives of 12 major corporations to define and confirm support for the research program of the partnership.

The partnership is focusing on the development of new or improved products and processes in technical areas where one company would find it difficult, if not impossible, to amass the needed resources of expertise, equipment, and funding. To perform the required basic research, ACCP will award research contracts to outstanding individual university researchers and to university research teams.

In addition, ACCP will create a central laboratory where a small number of outstanding industrial scientists and engineers will conduct more applied R&D directly in support of the industrial sponsors. This central laboratory, which will be directed by an active board of directors drawn primarily from the corporate sponsors, will serve as the "common ground" for the researchers from the sponsoring companies, the participating universities, and the research partnership. Here we will establish the stimulating environment where most of the technology transfer will occur through human interactions.

In addition to industrial sponsorship, the partnership will also seek funding from other sources such as the federal government and private foundations. In this way, ACCP will leverage the investments of the private companies while improving the nation's capabilities to compete internationally in this critical technological area.

The Midwestern Response

In conclusion, I would like to reiterate what I believe is the appropriate Midwestern response to the alarming trends in R&D funding.

First, I believe that we have to recognize the severe disparities in federal and industrial R&D funding that exist among the regions. We have to understand that these disparities have profound negative implications for future regional economic growth.

Second, we Midwesterners must speak with one voice to make the Administration, Congress, and key federal officials aware of these inequitable R&D funding patterns. We also have to make the industrial leaders across the country aware that such distorted allocations of R&D funding undermine their attempts to become more competitive.

Finally, because we already have a mechanism for regional technology development in place, we must act together to form cooperative R&D partnerships. Such partnerships are required to capitalize on the Midwest's assets and to compete more effectively for federal and industrial R&D funding.

Only by mounting such a collaborative response will the Midwest have the muscle to have any real impact on the federal government and major U.S. corporations. Only through regional cooperation can the Midwest hope to get out of the backseat as far as R&D funding is concerned.

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