Testimony on Importance of Basic Research to U.S. Competitiveness

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Chairman Ensign, Ranking Member Kerry, members of the Committee, thank you for the opportunity to testify today on the importance of basic research to U.S. competitiveness.

Texas Instruments is a company with a 75-year history of innovation. While our products have changed many times over the years, we have always fundamentally been a company of engineers and scientists. We have always looked to the future by investing in R&D. Based in Dallas, TI has become the world's third largest semiconductor company.

American competitiveness is the highest public policy priority for TI. We view increased investments in basic research, along with math/science education and access to a skilled workforce, as the three critical components to the future competitiveness of both our company and our nation.

Research and Investment

Let me provide an example of the power of investment in research on economic development. Three years ago, Texas Instruments had a $3 billion decision to make about where to locate our new semiconductor manufacturing facility. We looked at sites around the world, and many countries offered attractive incentives.

This year, we will complete construction on our new state-of-the-art facility – in Richardson, Texas, a Dallas suburb. When operational, it will produce the most advanced semiconductors in the world, support over 1,000 direct jobs, and bring thousands of indirect jobs to the Dallas area. An economic impact study estimated the investment would generate $13.2 billion in expenditures, $7 billion in gross product, and support 82,404 permanent jobs in the Dallas/Ft. Worth area.[1] The total cost of the construction is $321 million. Of that amount, 25% was spent with minority –owned businesses and more than 10% with women-owned businesses. This was an aggressive goal that we believe had never been matched in the Dallas area.

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[1] The Perryman Group. *Economic and Fiscal Impact of Texas Instruments 300mm Wafer Facility and Collateral Investment at UT Dallas*, June 2003.

The new facility has environmental and energy conservation innovations, with anticipated 20% energy reduction, 35% less water usage, and 50% emissions reduction. For the facility, TI received the 2005 Summit Award for Environmental Excellence from the *Leadership in Energy and Environmental Design* program of the U.S. Green Building Council.

Research was *the* critical decision factor for making our investment in Richardson. First, access to our R&D staff based in the Dallas area drives better time to market. Second was a commitment by the state to invest $300 million at the University of Texas at Dallas to further develop research and engineering capacity and improve the innovation ecosystem of North Texas. The investment at UTD will enhance basic research capabilities in close proximity to several TI manufacturing facilities.

Co-locating research with manufacturing is critical in the semiconductor industry, as it creates an infrastructure that allows discoveries to go from “lab to fab” efficiently. Corporate R&D projects are frequently done in the same facility as volume manufacturing, to ensure smooth transition to the new technology with maximum yield. Often, new tools introduced in the R&D process become part of full-scale manufacturing.

TI invests $2 billion annually, or 15% of revenue in R&D. Most of this spending is on the nearer-term “development” phase to ensure introduction of new products in an industry with short product cycles. In our high-performance analog division alone, we introduced 400 new products in 2004, and 50% of that division’s revenue was from products introduced within the past few years.

Leading-edge semiconductor companies are on a two-year cycle in reaching the next “technology node,” which is characterized by smaller and smaller critical dimensions of the components on a chip. For example, the minimum dimensions of individual transistors[2] are currently less than 50 nanometers.[3] This is an outstanding example of nanotechnology in volume production today.

Basic Research Critical to Semiconductor Industry

In 1958, when Jack Kilby invented the integrated circuit at TI, many were skeptical about his discovery. NASA and the Defense Department were among his first supporters in the late 50s, and federal support was critical to developing the manufacturing technologies in the mid 60s and 70s. Today, the worldwide semiconductor industry posts annual sales of $213 billion, with U.S. companies capturing about half of the market. The semiconductor industry employs a workforce of 225,000 in the U.S. Semiconductors have revolutionized the way we live, with computers, cell phones, broadband, television, medical imaging, and global positioning systems.

Another more recent example is Texas Instruments’ Digital Light Processing (DLP) technology. DLP is used in televisions, business projectors, and cinemas. The digital mirror device technology that underlies DLP was originally developed as part of the High-Definition Display Systems program at DARPA. Initial research started in the late 70s as part of an effort to improve aircraft cockpit displays. DLP technology now employs over 1,000 TIers in Dallas.

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[2] A transistor is a component device that opens or closes a circuit.

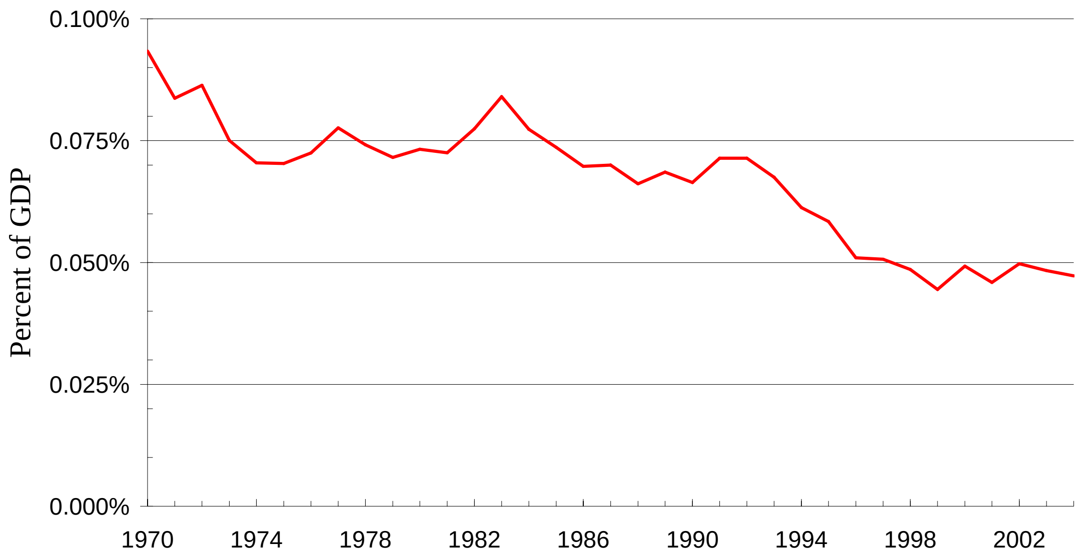
[3] A nanometer is one-billionth of a meter. A human hair is roughly 50,000 nanometers wide.

Overall, the U.S. chip industry invests 15% of revenue in R&D, one of the highest of any industry. However, given short product cycles, most funds are for relatively near-term development activity. For the majority of longer-term basic research, TI and other companies in the industry depend upon activities at universities and federal labs.

The federal government is uniquely positioned to fund basic research. It historically has been a primary source of basic research funds for universities. The federal government plays an important role in supporting higher-risk, exploratory research where the economic benefits may not be realized for decades.

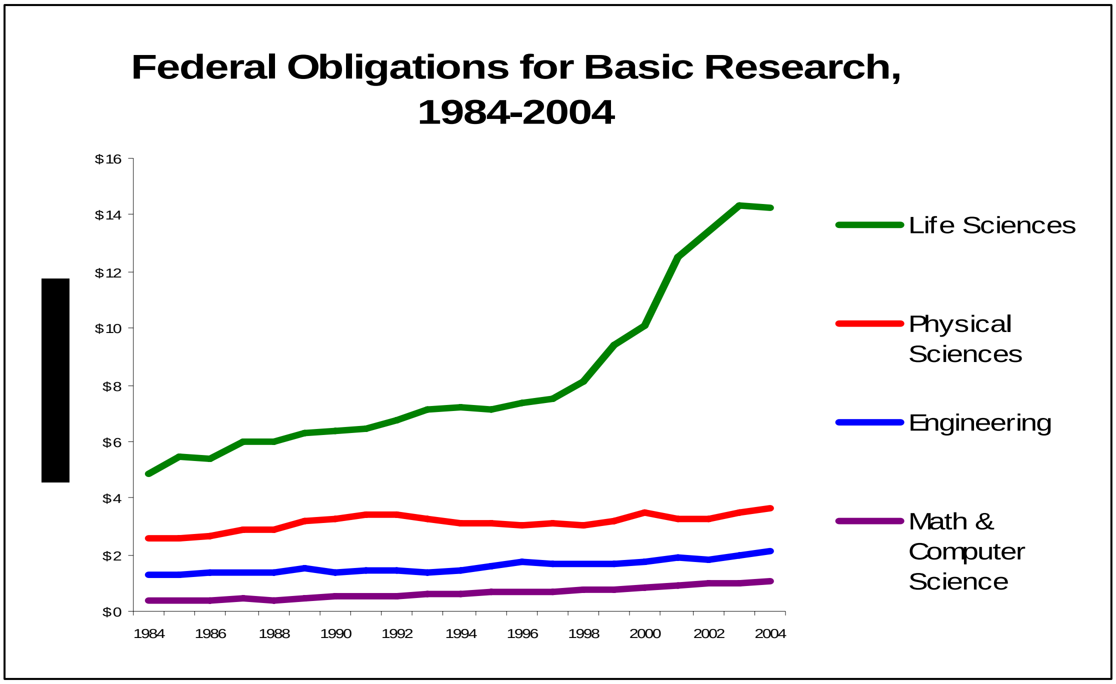
Yet, federal investment in basic research has not kept pace in key areas such as engineering and physical sciences, whether for semiconductor related research or other areas of inquiry. It has been essentially flat for three decades. As a percentage of GDP, it has declined.

Federal Investment in Physical Sciences Research in Significant Decline



Source: American Asssociation for the Advancement of Science. http://www.aaas.org/spp/rd/guidisc.htm. Compiled by the American Physical Socitey Office of Public Affairs.

While investment in the life sciences has grown exponentially, federal resources in the physical sciences, engineering, math, and computer science have been stagnant. These neglected areas must be revitalized, at least at the levels proposed in the Administration's American Competitiveness Initiative.



Source: American Association for the Advancement of Science

There has also been a portfolio shift toward development activities, often at the expense of basic research. At the Department of Defense, basic research as a percentage of the total science and technology portfolio declined steadily from 1994 to 2004, to 11%.[4]

For the past forty years the chip industry has been delivering on Moore's Law, which states that every eighteen to twenty-four months the component content of a semiconductor chip will double. This means faster, more powerful and less expensive semiconductors. The Bureau of Economic Affairs estimated that federal, state, and local governments saved a cumulative $181 billion in computing price declines from 1995-2004.[5]

But, to continue to deliver on Moore's Law, significant research hurdles must be overcome. The chip industry has mapped out the technical challenges it faces and the research needed to adhere to Moore's Law. Each year, the industry brings together 1,000 technical experts and updates the International Technology Roadmap for Semiconductors (ITRS). The ITRS identifies several hundred technical challenge areas that collectively comprise a "red brick wall"—in other words, problems for which there is no known manufacturable solution.

Collaborative research with outcomes expected in three to eight years requires industry to pool its resources and partner with government. Longer term research – 8-15 years out – involves government sponsored university research through the National Science Foundation, the Department of Defense, the National Institute for Standards and Technology and others to undertake the most fundamental research that will result in completely new technologies in the coming decades.

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[4] American Association for the Advancement of Science. Trends in DOD S&T, February 2005.
[5] Bureau of Economic Affairs www.bea.gov/bea/dn/comp-gdp.xls.

Industry experts agree that a replacement technology for the current 30-year old semiconductor process,[6] which is reaching its physical limits, needs to be discovered and manufactured by 2020 to continue the historical trends of performance enhancements, size reductions, power conservation, and cost savings. Seminal research papers usually appear 12-15 years before commercialization, in other words *within the next few years*.

Key Agency Partnerships: Defense, NSF, NIST

The Department of Defense has historically been a funder of basic research in the physical sciences. However, in constant dollar terms, the level of basic research (6.1 account) at DOD was the same in 2004 as it was in 1984.[7]

The Focus Center Research Program is a partnership between the Defense Department and the semiconductor industry to fund university research at 33 institutions nationwide. All funding goes directly to universities, and funds research centered on the key technical challenges to extending the life of the current chip-making process and transition to the next technology. Federal funds are leveraged through an industry match, which is very rare for a basic research program. This is an excellent example of the type of activity the Defense Department can support with the basic research account. DARPA has been a great supporter of the program, providing both funding and expertise. Yet unfortunately, the Defense Research and Engineering request for the program has been at zero the past few years, requiring Congressional additions for the program to be fully funded.

The National Science Foundation is also critical to funding basic university research in the physical sciences and engineering. The Nanoelectronics Research Initiative (NRI) is a cooperative effort co-funded by NSF and the semiconductor industry to support university research to find the next generation of semiconductor technology by 2020.

Other countries are investing heavily in the nanoelectronics research area and could surpass U.S. discoveries in this area. If the U.S. does not discover and capture the new technology first, the U.S. semiconductor industry will be at a global competitive disadvantage. The NRI partnership will be key to this effort, and is an excellent example of how industry and the NSF can work together.

The National Institute for Standards and Technology (NIST) has ongoing activities relevant to the industry in semiconductor/electronics metrology (measurement), nanomanufacturing, and quantum information science.

Research and Workforce

Finally, basic research is important in terms of developing a workforce skilled in science and engineering. Many of the funds provide stipends for graduate students to conduct research in these fields, both during the course of their education as well as post-doctoral opportunities. It has been well-documented that students follow the money. Basic research in this capacity contributes to building the pipeline of students with advanced degrees in science, technology, engineering, and math fields. In turn, this builds a skilled U.S. workforce for our businesses.

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[6] Complementary Metal Oxide Semiconductor (CMOS)

[7] American Association for Advancement of Science. Trends in Basic Research, March 2005

Foreign nationals represent a large percentage of graduates from U.S. universities in science and engineering fields. In 2005, 55% of the Masters and 67% of the PhD graduates in electrical engineering from U.S. universities were foreign nationals. Electrical engineers are in high demand, with an unemployment rate of only 1.7%. Unfortunately, current policies and long wait times for permanent resident status are a disincentive for these degree holders to stay in the U.S. and contribute to our economy. Most of these graduates have participated in important basic research at universities. Companies like Texas Instruments need to be able to access all talent graduating from U.S. universities, regardless of nationality. Employing these individuals in the U.S. private sector also assists the nation in capturing returns on basic research investment.

Role of States

State governments are also critical in supporting public research universities from a budget perspective. In addition, states play an important role in facilitating commercialization from universities to industry. For example, Texas created a $200 million Emerging Technology Fund. The fund has three goals: invest in public-private endeavors around emerging scientific or technology fields tied to competitiveness; match federal and other sponsored investment in science; and attract and enhance research superiority in Texas. Several other states have similar mechanisms.

Last year, the President's Council of Advisors on Science and Technology issued a five-year assessment report on the National Nanotechnology Initiative. One of the recommendations was to increase federal cooperation with the states, especially by leveraging state research investments. Further, the report recognized the important role of states in commercializing nanotechnology research results.

Conclusion

The American Competitiveness Initiative and 2007 budget requests on NSF, NIST, and DOE Office of Science will be critical to reversing the flat to downward trend in basic research in the physical sciences and engineering. The FY 2007 incremental increase is $1.05 billion, which in the context of the overall federal budget is relatively small. These increase requests are an investment in our country's future economic competitiveness, and should not be viewed as spending.

The technical challenges faced in the semiconductor industry provide just one example of the importance of basic research. The programs outlined in this testimony illustrate how the industry, federal government, and the states can work together to find research-based solutions that enhance our nation's competitiveness.

Finally, the role of university research in TI's decision on where to build its new facility demonstrates how investment in research can be a powerful economic development tool.

Thank you for the opportunity to testify today. TI appreciates the Committee's interest in basic research and its role in U.S. economic growth. We look forward to continuing to work closely with you on the broader competitiveness agenda.