CCR CTO Roundtable

The Future of the US Chemical Enterprise:
How can US Policy Enhance Chemical Science Innovation?

Washington, DC
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The Chemical Industry has recently joined the long list of US industries with a negative trade balance, and investments in chemical science R&D are following the migration of manufacturing to overseas. Chemical sciences are core competences for most industries and are vital for US efforts to improve its competitiveness and energy security. President Obama has proposed to increase US R&D investments from the current 2.6% to 3% of the GDP, but how can this be accomplished, and is it enough to reverse the tide?

The Council for Chemical Research (CCR) organized a CTO Roundtable to bring together science and technology leaders from industry, universities and the federal government to discuss ***the Future of the US Chemical Enterprise: How can US Policy Enhance Chemical Science Innovation?*** The Roundtable participants discussed some of the most important questions for the nation, including:

- Does an increase in US based R&D translate into an increase in manufacturing activity in the US?
- What type of tax and other incentives can the Federal government provide to encourage global companies to locate their R&D facilities in the US?
- What type of tax and other incentives can the Federal government provide to encourage global companies to locate their manufacturing facilities in the US?
- How can the Federal government encourage industry to increase its R&D investments in the US and contribute to the goal of the current Administration to increase total US R&D investments (public and private) up to 3% of GDP?
- How can the Federal government accelerate US innovation?

Leaders of the chemical science R&D enterprise from industry, universities, and government laboratories participated in this Roundtable. A list of participants and their contact information are provided in Appendix A.

OVERVIEW of CCR

CCR is a not-for-profit organization created in 1979; its members are companies, universities and government laboratories that conduct research in chemistry-related science and engineering in the US. CCR's goal is to benefit society by advancing research in chemistry, chemical engineering, and related disciplines through leadership collaboration across discipline, institution, and sector boundaries. More about CCR can be found at http://www.ccrhq.org

- CCR promotes partnerships in chemical science research – three pillars (industry, universities and government laboratories) are at the table.

- Effective partnerships are critical in a global and open innovation environment.
- CCR promotes partnerships among the three pillars by organizing: a) Annual Meetings where issues of national importance, such as the impact of globalization on innovation, competitiveness and education, are discussed as well as creating networking and "match-making" opportunities; b) Technical workshops to share technologies and new ideas; and c) Workshops to address barriers to partnerships such as IP issues, and sharing "best practices".
- CCR advocates for investments in chemical science research and sponsors studies assessing the economic impact of R&D investments.

BACKGROUND

Recently published ***National Science Board – Science and Engineering Indicators – 2010 Digest*** (http://www.nsf.gov/statistics/digest/) provided valuable background information for this discussion:

- Most developed or developing countries realize the importance of R&D investments for the economy; worldwide R&D investments have exceeded $1 Trillion.
- US accounts for about a third of these investments
- R&D growth rate for the US is about 5%, whereas Asia-Pacific region investments are increasing at an annual rate of 20%.
- Comparison R&D intensity by country, US investments have been fairly constant at 2.6% of GDP, while other A-P countries have exceeded 3%.
- In the US, industry investments account for two thirds of total R&D investments - not all for basic research
- About 50% of federal investments goes to life sciences – this situation is expected to change due to increased investments in physical sciences as a result of the American Competitiveness Initiative (ACI) and the America COMPETES Act.
- The US continues to rely on foreign born PhD's for its S&T talent pipeline; however, increasing numbers are going back to their country of origin especially in engineering, physical sciences, etc.
- US high-tech exports continue to decline, accounting to less than 15% of global trade, while China's share has increased to more than 20%.

The discussion at the **CTO Roundtable** was focused on three issues:

a) How can we improve the US Innovation climate?

b) How can the US encourage global companies to locate their R&D and manufacturing facilities in the US?

c) How can the US ensure the availability of technical talent for R&D and challenging jobs for new graduates?

The objective of the Roundtable was to come up with actionable proposals that can impact Congressional actions such as appropriations for FY2011 and subsequent years, authorization of the America COMPETES Act, PCAST deliberations, and other policy decisions.

This Summary Report is organized into three sections: a) Key Findings; b) Follow-on Actions; and c) Recommendations.

KEY FINDINGS*:*

A. How can we improve the US Innovation climate?

There are good things we can build upon:
Congress is in the process of reauthorizing the America COMPETES Act, and is looking for input from industry, especially on actions that could help expand US innovation capacity and create jobs. At a recent House S&T Committee hearing, Presidents of the Business Roundtable, US Chamber of Commerce, National Association of Manufacturers (NAM), and Council on Competitiveness (CoC) testified about the US innovation capacity, and in support of the reauthorization of the America COMPETES Act. They emphasized the need for an Innovation Agenda at the national level, making the R&D Tax Credit permanent, and investing in game changing, transformational technologies.

In order to compete, the US should invest in the transformational areas of new technologies to keep domestic manufacturing strong. Alternative energy resources and related materials represent a major opportunity – e.g., biofuels, biofeedstocks, solar energy, and light weight cars (where chemistry and polymer sciences are important). The US continues to have an edge in bio-based research and innovation; often begins in universities, leading to spin offs; resulting bioprocessing related manufacturing activities usually remain in the US. We need to expand investments in these areas.

However, the US needs a national strategy and a plan. How can we make the US a better place for investment in manufacturing? Commerce Secretary Gary Locke said, in his presentation to the PCAST, that the US has “a broken innovation eco-system.” What are the road-blocks to fixing it? Steady, predictable funding? Risk sharing by industry and government? Tax incentives and predictable tax policies?

Roles are changing, and we need to think carefully about impacts:
Leading US research laboratories (Bell Labs, IBM, Xerox, etc.) and many other corporate research laboratories have either disappeared or significantly reduced in size. We are relying more heavily on universities to feed the innovation pipeline. Are the universities prepared to take on this responsibility? What can be done to make the system more effective?

In its current state, US graduate education in science and engineering has become too restrictive and rigid; students must work on projects the professor has funding for. Creativity and innovative spirit of the graduate researchers are limited by the granting system. The graduate education system has become more rigid than it was – and this stifles innovation. Further, there is a disconnect between how university research is carried out and how industrial and government laboratory research is carried out. The industry/ government research climate is characterized by working in groups on large projects; and the rewards system encourages team work.

The current system tends to create young researchers that are clones of their research advisors; new young investigators don't have a chance of getting funding unless they build on what their advisors did. Our current funding programs do not encourage students to come up with new ideas; this must be modified to encourage innovation. A model to be studied the Howard Hughes Medical Institute. They fund the best and the brightest; funding for a minimum of $5 M for 5 years, and encourage innovative thinking.

We know we need to work together, but it's a challenge:
We need a different model of collaboration between industry and universities; concerns over intellectual property rights have gotten in the way; often it is easier for industry to work with universities outside the US. There was a general agreement that there are incompatible expectations between universities and industry. Getting a mindset and focusing on intellectual grand challenges instead of fighting over IP would be helpful; the Bayh-Dole Act has raised unrealistic expectations. Graduate education used to be solely about education, it is now expected to be the engine of economic growth. Universities are now being pushed to focus on technology transfer by state governments despite the fact it often is a drag on the universities.

Those working at the industry/university interface recognize what is not right – but are not sure about how to fix it. The current university model focuses on short term benefits, rather than long term benefits that collaboration with industry could provide. What is the mechanism to ensure that universities get their payback? Industry wants the professor to benefit, but the expectations upfront by the universities are unrealistic. There are many variables – marketplace success is never guaranteed. Business practices and profit margins have to be taken into account. Education is required at the academic and industry interface in order to move away from mistrust, and we must rethink how we carry out graduate education in order to develop innovation skills.

B. How can the US encourage global companies to locate their R&D and manufacturing facilities in the US?

Does R&D automatically mean manufacturing jobs as well?
The Federal government has not always done a good job connecting R&D to job creation. The de facto business model is to fund research and let it flower – without thought of where this would happen and where the manufacturing would be performed. This link is not automatic. While the Obama Administration announced a Strategy for American Innovation: http://www.whitehouse.gov/sites/default/files/microsites/ostp/innovation-whitepaper.pdf, there also needs to be tax policy to encourage US manufacturing. There are several examples of where such policies have been effective:

- Puerto Rico was one a favorite site for pharmaceutical manufacturing because of tax incentives; most have moved to Ireland now as a result of more favorable tax incentives and investments in their universities to improve their talent base.
- Singapore has made a conscious decision to promote biotechnology by providing R&D funding, tax incentives and recruiting world's best research leaders.
- Novartis has made an extraordinary investment in the Cambridge, MA area, to take advantage of the talent base, large federal R&D investment as well as great university talent.

There are counterexamples as well; what are the deciding factors?

- Intel decided to locate its manufacturing in Texas even though it costs more – what did they know? What are the barriers and impediments – how do we encourage investing in manufacturing in the US?
- Province of Alberta and the university are serving as an anchor for technological development and manufacturing.
- BMW established manufacturing in SC near Clemson.

NSB S&EI 2010 report talks about this – US lead is slipping in value added manufacturing; we need renewed focus on basic research and manufacturing. Agencies such as NIST and NSF should be supported, especially those programs that promote manufacturing. ARPA-E was launched last year – it not only supports transformational science, but also provides funding to get technologies through the valley of death. NIST ATP Program was designed specifically to address the valley-of-death issue; is there any hope of rejuvenating that program? The President continues to support the vision of doubling the R&D budget of agencies such as NSF, NIST and DOE Basic Science.

Is it time for a new model for manufacturing?

Could the federal government create manufacturing hubs, with national labs, universities, companies? The current administration is receptive to policy experiments to improve US innovation. There may be opportunities to try the concept of a hub in the clean energy sector; going forward they would be able to see where the successes are, and where the shortcomings are; could then revise policies accordingly over time. There are already some good examples in the nanotechnology area. Additionally, state and local government also have a critical role in job creation. We need to make sure there are no barriers to getting up and running in the US, so that companies do not go off-shore. National strategy that brings federal, local and state governments together would be important to keep manufacturing of transformational technologies in the US.

However, there is no agreement that R&D and Manufacturing are necessarily connected. Some feel that there is no strong linkage between where R&D occurs and where manufacturing is done. A plant can be put anywhere; it goes where the markets are, materials and feed stocks are available, and the costs are favorable. Cost of transporting materials and products are less of an issue today. So the question is refined – what manufacturing would we want to have in the US? How to incentivize that? We need to think about the manufacturing part first, and then think about the R&D and infrastructure to support the manufacturing capabilities.

Renewable energy and sustainability represents a large area of investment; US represents a large market; products that are developed to meet US needs will find markets in other parts of the world. Companies are looking to where the talent is – we need to develop the local talent. Great ideas will go to short term opportunities if there is no US strategic plan. Investments in clean energy technology will create jobs. Time seems to be right today – we are investing in a future and the Administration sees this as a focus area. Also, there are comprehensive climate and energy legislations; they will set the boundaries on what type of technologies need to be developed. This encourages innovation since current technologies will not get us there.

How to we ensure we capture the best ideas?

Our best has come out of working together on grand challenges – but industry has been missing lately from the table. A CTO Advisory Group would help facilitate engagement.

PCAST members are CEOs, with very little representation from the manufacturing sector. CTOs would be interested if the agenda is of interest and action is taken on their recommendations. If the OSTP advises the President it would be good to have a formal mechanism to regularly convene CTOs – this could be the logical next step. CTO of the federal government could convene this group, which could also include National Lab Directors. CTO advisory group would: a) Identify key technologies; b) Help structure a high level integrated plan; and c) Help with decisions on public investments.

C. How can the US ensure the availability of technical talent for R&D and challenging jobs for new graduates?

There are more questions than answers:

- The university's role is to prepare the next generation workforce – how do we make sure they are working on the right things to become part of the country's innovation capacity?
- The Federal government has a de facto business model for R&D – more R&D investments makes linearly better outcome; this may not be true. We need the right kind of people for the new model – how are the universities adjusting to these new realities?
- Public education is failing the next generation, especially in many urban environments, snuffing out much potential. Everyone should have access to good science education, irrespective of their eventual career choice – how do we make that happen?

We have the people, but we need to make sure we adapt to changing times to ensure that talent pool is prepared to enter the workforce and maintain the US economic advantage. Today the US is the go-to country for S&T education. As a country, we need to have our citizens participate in the S&T enterprise, but there is deterrence; a newly minted undergraduate in science might choose going into law and make a much higher wage than a new PhD or post-doc who comes out of the system much older. Should we consider restructuring the PhD program? The time to degree is very long, and this is partly related to funding structure. We expect a lot of the student – and should get them to the independent phase of their career sooner. We do need to be careful – the UK moves people through quickly – but they are not as scientifically mature as US students. There needs to be balance.

There is agreement we are not providing PhDs ready for the industry world early enough. The traditional postdoctoral experience – professional researchers drained by their mentor to get results - is not encouraging innovation. Industry and government labs need better prepared students, with good team skills, and international skills. It is likely that universities are not fully aware of the environment and needs of the industrial and government lab researchers. NSF sponsored the IGERT (Integrative Graduate Education & Research Traineeship) program, but it is too small. NSF also has the GOALI (Grant Opportunities for Academic Liaison with Industry) program – but we need a grand program – bigger model of partnering. More and more PhDs are going to small companies; such experiences will be critical for new graduates.

The US benefits greatly from international students, but there is still a visa problem. There are simple solutions - foreign students should be granted visas for multiple return visits and those graduating should get an automatic green card to stay in the US. In an

every globalized economy, US students need cultural education and international students need to understand US culture and values, and we should be supporting educational efforts that lead to these outcomes.

Not everyone needs a PhD:
There needs to be a greater investment in STEM education. Programs where industry partners with secondary schools and community colleges – and provide training for high technology jobs – are very attractive. How can we partner to expand these programs? We need to develop a clearinghouse of best practices; internships, visits to industry, professional development courses – including entrepreneurship.

There is a supply and demand problem for new graduates; can we come up with a better way of projecting needs; are there buffering mechanisms to help with periods of slow down? What is the real jobs situation for Ph.D. researchers? Is there a lack of demand for PhD graduates? Should we focus on MS and BS workers? What do you do with all the researchers the system generates? One mechanism is to create permanent professional staff positions in university research institutes. Industry and government labs usually have much shorter term budget process; this creates a mismatch with academic timelines for graduate students, but not for professional research staff. Research Institutes with professional staff ease the coupling between university and industry research; such institutions can and must be entrepreneurial and innovative. There are several models in Europe for University/Industry imbedded programs.

The bottom line:
In the US, there is a fundamental lack of appreciation for S&T; in many other countries, engineers and scientists are considered the cream of the society; in the US, business positions are much more desirable – so we need to bridge the gap. It is the obligation of the three pillars to bring renewed focus on the importance of S&T for the future of the US economy.

FOLLOW-ON ACTIONS

1) Organize another CTO Roundtable with Department Chairs:
Topic: How to improve graduate education to make it more applicable to non-academic needs? Invite PIs of the IGERT and GOALI grants.

2) Organize a workshop on High Performance Computing, in collaboration with DOE Office of Science.
The national laboratories are creating many computational tools that could accelerate R&D and commercialization of new technologies in chemical sciences; they are not being utilized by industry. Increase industry awareness of such tools.

3) Develop better ways to get the message out on S&T issues
We make it much too intellectual. How do you convey to the general public – how do we sell our message? How do you make it exciting? You have to think outside the box – use technology especially to reach young people. Showcase STEM careers, female and minority scientists.

4) Develop a white paper on "STEMming the Decline of US Manufacturing" (how to create a new manufacturing model?).
Create a voice for manufacturing – there is not a single unified voice now; find a "Norm Augustine" to champion the topic. What will enable US to be successful? Tell the whole story of innovation - how it is really done. Emphasize relation between R&D and Manufacturing.

The current advocacy in Washington is to preserve old manufacturing and not establishing new; we need to focus on new manufacturing technologies. Identify technologies for which there is a large US market and reason to meet in the US (logical co-location of meeting and market). Where can federal funding make a difference? Look at models from other countries.

RECOMMENDATIONS

1) Increase industry participation on existing key policy boards and committees – give industry more of a voice in decision-making (e.g., NSB, PCAST)

CCR ACTION – let members know of the call of nominations and deadlines for existing committees and boards

Need a personal commitment from leaders of companies and universities to meet with agency leaders. Assurance that they would not be ignored or be made to wait – industry concerned about the time it takes to talk with agencies, plus the lack of any outcome.

There is not a lack of industry interest – but interest wanes when there is no action. Is there federal money available? People are more willing to talk if there is federal funding to support engagement and recommendations. Getting together is time consuming – we need to shape the debate first.

Shaping policy is tough. There is no instant lever. However, if you don't engage you will not affect the policy. PCAST will be looking at R&D tax credit and Growth for R&D in the public sector; this is an opportunity for industry to get involved. At this point in time, economic stress is driving experimentation. If changes are going to happen, we are better off being part of the discussion.

2) Identify one (or more) grand challenges and work through an integrated plan for solving the problem and implementing the plan. Create a CTO Forum to address this topic(s) for the chemical science enterprise

What are the opportunities for job creation? Energy related alternative technologies?

Revolutionizing transportation – is that such an opportunity? We need to identify where we need to end up, this is where we are – how can we get there? Write the grand challenge narrative with strategic and integrated plan

Grand challenges for the chemical community: Feedstocks. If there is no reasonable access to feedstocks, manufacturing will not be in the US. There is a desire to incentivize feedstocks for transportation fuels – but not for making other products.

Also need to address revolutionizing transportation (biofuels, H_2, vehicles/types, fuel cells, are these right priorities?); focus on a 20-50 year time frame

Suppose we redesign transportation in the future – where are the $$ being invested? are they aligned? The research agenda must be defined by industry, and that's where the funding should go; academics will chase the money and the right research will be done. Investments should be aligned with short term as well as the long term.

What manufacturing do we want to retain in the US? We need to identify a strategic end state; we should then develop a roadmap with flexibility to adjust.

3) Develop a white paper on the 2nd Chemical Revolution – Rapid pathways to the market (accelerating R&D)?

We need to think about the manufacturing end – what do we need to do to get there? Articulate why we would want to do it here in the US!

What will the chemical industry of the future look like? Can we build tomorrow's industry on today's technology? Will there be transformational changes, or will we be doing the things we are already doing better? Decision makers are looking to the technology community for input. We need to keep in mind that this is an economic issue. **Focus on jobs and the chemical enterprise!**

Action that could come out of this is to identify some broad segments even sub-segments that could provide jobs in the US. We could start in 3 or 4 areas – a strategy of how to rebuild. There are models out there. Singapore established a strategy on what business they wanted to attract, and that became the R&D of what we want to fund. Has there been a study on this - different models that have been used to bring jobs and manufacturing to their countries?

Which areas of academic research/ basic science to invest federal funding in? Many areas needed by industry are not being funded or studied. Take longer time horizon in assessing areas needing research.

4) Encourage predictable tax policies and environmental policies (emissions regulations, carbon tax, etc)

Predictable Government tax incentives for manufacturing, such as a reduced corporate tax rate and a permanent R&D tax credit, would go a long way to encourage R&D investments and capital investments in manufacturing.

Long awaited decisions on global climate change policy and related carbon tax or cap and trade discussions have added to the uncertainties of decision making, and delayed investments in new technologies or stopped development of alternative technologies.

To keep manufacturing in the US, scale up of new processes should be done near R&D facilities; this is a very expensive step; unfortunately permitting issues and other environmental regulations make the process too slow, and too costly in US. As a result,

companies build such facilities elsewhere. Large scale manufacturing facilities end up following the same route.

5) Enhance research capabilities of universities to address industry needs and future technology needs of the country:

Topics for consideration:

- Utilize federal research funding for transformational technologies
- Utilize professional researchers to improve matching of time lines
- HHMI model for funding researchers rather than proposals
- Hiring buffer between graduation and industry jobs, e.g., university embedded research institutes
- Develop new models of engagement between universities and industry, e.g. co-op/internship programs in industry with government funding, university research parks, MIT Practice School Model

Restructure graduate education to prepare graduates to be independent researchers before age 30. Also prepare them for an industrial R&D career through programs such as the UK Cooperative Awards in Science and Engineering Program (involves industry experience).

6) Develop new University-Industry research collaboration models

- Address IP issues to prevent them from being show-stoppers
- Address adequate funding
- Create opportunity for grad students to experience industry culture (see above)
- Provide training for academic and industry collaborators

7) Create a Council of CTO Advisors for the White House

Could have a group of CTOs from Chemical and Allied Industries – to address big picture issues and take their findings to DOE, USDA, Commerce, or people on the Hill. They would like to hear from a combined group – not just one company. The need and timing are there. This is a window of opportunity to make serious input on the future of our economy.

Appendix A

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