Government and Innovation: *Measuring the Impact*

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A nation's competitiveness relies on the proper balance of several components including education, federal science funding, immigration, and incentives for private sector R&D investment. Many studies conducted over the past few years have highlighted the need for strengthening these components through increased funding and enactment of favorable policies. The Council on Competitiveness provided a framework for moving forward in their report *Innovate America*. The National Academies, *Rising Above the Gathering Storm*, assembled a comprehensive list of findings and recommendations. These, and other thoughtful pieces, informed our national strategy which was embodied in the America Competes Act.

Throughout the discussion of competitiveness – the issue of innovation arises. Enhanced innovation is a consequence of getting the competitive components in sync. It is not something the government can legislate – but the right competitive environment can foster greater innovation.

Though the appreciation for innovation has increased – it is still unclear how to measure the impact of government policies on innovation. In fact, determining appropriate metrics for measuring the impact of policies on innovation is critical. As Lord Kelvin once quipped, "*If you can not measure it, you can not improve it*".

For this discussion, I loosely define innovation as "*invention that impacts the business*". For example, a brilliant idea is not an innovation until it is introduced into the marketplace. A new law of physics is not innovation. But a specific innovation may only be possible due to advances in our basic understanding of science. So for innovation to occur – we need a way to generate a "brilliant idea" *and* move it into the marketplace.

If the people who generate ideas are different from those who produce products, then inefficiencies arise. One manifestation of this inefficiency is the "valley of death" which describes the chasm between knowledge discovery and commercialization. In traditional science policy, knowledge discovery generally occurs in academia and commercialization in industry. Thus unless there is a smooth connection between these entities, a gap can occur.

One method of measuring the impact of government policies on innovation might, therefore, include whether the policy widens or narrows the "valley of death". For example, what impact do our visa and immigration policies have on transitioning ideas into products? Does educating the world's intellectual elite and then forcing them to leave the country help or hurt our innovation?

There are many government policies that impact our nation's innovation -- but there have been few quantitative analyses to assess their cost and benefit. In this talk, I will delve a

little deeper into one policy: the Federal government's view of how scientific advances are transformed into new commercial innovations.

For more than half a century, the Federal government has used a research and development model that assumes a smooth transition from basic science to applied research to development and eventually to commercial production.

The government's view is that basic science should be pushing the frontiers of knowledge without applications in mind. Eventually a potential application of this new knowledge will arise leading to applied research and development. This simple linear model is firmly embedded into the very fabric of the Federal science and technology enterprise. The only problem with this linear model – is that it is wrong.

The transformation from basic science to commercial applications is not a smooth straight line. Advances in science inform commercial entities what may be possible – and commercial needs inspire the science community to pursue new avenues of research.

For example, the semiconductor industry is well aware that physical laws will limit how small they can eventually shrink their existing chip architecture. This eventual limit is now driving university research into new architectures that may be embedded in the electronic products of the future. In other words – commercial needs in the semiconductor industry are driving segments of the basic science research. This is completely backwards from the Government model.

What are the consequences of using a simplified model for science? In the Federal government's view, there is a specific demarcation point whereby Federal funds must end and the private sector begins. But in reality, as described earlier, the transition is not smooth but iterative with feedback from both sides. By creating a rigid and artificial boundary, the feedback breaks down and the iterations cease. Thus a gap is created whereby basic research is left on the shelf and not used to generate wealth.

In an attempt to assess whether this artificial gap has been increasing or decreasing, I examined the federal government's basic and applied science funding profile over the past 2 decades. Since 1990 (in constant dollars) the total basic science budget has doubled with almost the entire increase going to universities. The federal funding going to industry in absolute dollars was flat -- and as a percentage of the total was cut in half. That may not be too surprising since basic science is viewed as the primary domain of academia.

But a more surprising, and potentially negative effect is observed within the *applied* research funding. In 1990 industry was the largest recipient of federal applied research funding. Unlike the basic research – the total applied research funding has seen only a modest increase. More surprising, however, is that the industry funding actually *decreased* – with the fraction more than cut in half. In 2005 universities and government intramural programs – neither of which bring products to market – each received more federal *applied* research funding than industry.

Another way to look at it: is that in 1990, industry received about 50 cents of federal basic and applied research support for every $1 going to academia. In 2005, the industry support had dropped to only 14 cents. Thus the capacity of industry to identify, mature, and commercialize new ideas generated in academia seems to have decreased. From a measurement perspective -- how does the government funding affect the gap between universities and industry?

The U.S. is second to none in research dollars, intellectual power, and innovative industries. But the rest of the world has watched, learned, and is adapting. The U.S. needs to get more sophisticated in its analysis and understanding of policy options. We need to objectively measure the impact of policies and be willing to experiment with new policy ideas and change policies as needed.

If we are to stay competitive, we must be at the peak of our game. That implies understanding how research is really accomplished and integrated into the economy and aligning our policies across the full spectrum of actions. The consequence of not optimizing the science and research enterprise would be to envy the "glory days" while the rest of the world innovates right past us – allowing them to reap the economic rewards.