Extended Abstract: **Origins of Disagreements about Government Support for Radical Innovation**

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We start by noting that innovation differs from creativity. Innovation corresponds to ideas that are implemented, while creativity is the generation of ideas for ideas sake.[2] Ideas do not create jobs until they are implemented.

Innovation is often divided into two categories: radical innovation which leads to new industries and new markets; and sustaining innovation which maintains the competitive advantage of existing industries. Unsurfaced but divergent normative assumptions are obstacles preventing realization of a coherent U.S. policy on government support for radical innovation.[3] The normative divergence on the means to achieve radical innovation stands in sharp contrast to the shared goal of the creation of new businesses, mass employment, and expanded markets. Superficially, this lack of agreement appears all the more puzzling when it has long been realized that government support was a key to establishing such radically new and presently pervasive industries as aerospace, semiconductors, and the internet.

To identify the origins of this divergence, we adopt a functional analysis of the elements required to mature a concept into a fielded solution. We find that the elements required to create an enterprise that arises from an initial concept are the same whether a proposed radical innovation addresses the commercial market or a specific government need. Implementation of ideas, a.k.a. innovation, requires satisfying the constraints of a sustainable business. After the "aha" moment, the potential innovator has to generate the appropriate technology, demonstrate proof of principle, identify a specific product that meets either an explicit or latent need, mature the technology, develop a means of production and continuously improve both the product and the production infrastructure. The potential innovator must create a distribution chain to provide the product to paying customers. If addressing a commercial market, the innovator must develop mass marketing campaigns to attract consumer interest. All this must be done while managing cash flow to pay suppliers and meet payrolls. The potential innovator must then carefully manage the evolution of the enterprise through judicious choices.[4]

We find that when government historically has invested to address a problem of national concern,[5] there is large consensus of the appropriateness of public funds to carry the concept through to production and distribution. For sufficiently important problems (improved warplanes in the case of the Cold War, advanced electronics for the warfighter in the case of semiconductors, and nuclear command and control in the context of the ARPANET), commercial considerations were second in importance to achieving the required capability. In the cases mentioned above, government supported the early research and development for the innovative solutions. Public funds supported the required production enterprise and even paid for improvements to the means of production. Most importantly, government provided an early market that provided the steady revenue to sustain the enterprise.

In the case of government investments for national concerns,[6] shared policy priorities provided the normative framework for the investment. This consensus disappears when public funds are proposed to support the radical innovation that solely target the creation of large new commercial markets.

Today's disagreements about applying public funds for job creation through radical innovation focused on commercial markets are understandable in the context of the requisite steps to convert an idea into an enterprise. In the absence of public agreement about support for radical innovation, achieving the requisites for a viable business is left as a challenge to the innovator. Most recently, public attention has focused on the "Valley of Death" which can be described as the need for the

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[1] Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

[2] Theodore Levitt, "Creativity is Not Enough" Harvard Business Review, August 2002, pp. 137-144.

[3] Rachelle Hollander, "The Role of Normativity in Science, Engineering, and Technology Policy," available at: http://www.aaas.org/spp/rd/forum2010/

[4] D. R. Myers, C. W. Sumpter, S. T. Walsh, B. A. Kirchhoff "A Practitioner's View: Evolutionary Stages of Disruptive Technologies," IEEE Transactions on Engineering Management, Vol. 49, NO. 4, November 2002, pp. 322-329

[5] C. W. Sumpter and D. R. Myers, to be published.

[6] Rachelle Hollander, op. cit., identifies defense and economics as the few shared national priorities, to which we would add health.

nascent enterprise to absorb a negative income during its early development in anticipation of future revenue from ultimate product sales. This initial negative income acts as a barrier to scaling the successful proof of concept into the mass production needed to service mass markets and create new jobs.[7] As policy makers examine who should support each of the steps from proof-of-principle demonstrations to ultimate creation of mass markets, ideological differences can prevent consensus regarding which is the role of the public and which for the innovator. Should the public fund the research and development that leads to proof of concept? Should the public fund technology maturation for an uncertain market? Should the public support scale up of production for emergent products? Is there a role for public investment in developing distribution channels, let alone marketing? How strongly should government regulations impact market creation? What is the role of fiscal and tax policy? What are the roles of antitrust legislation, export controls, etc.? The answers to those questions depend strongly on one's perception, let alone ideology, regarding public vs. private responsibilities.

Three additional observations arise from this analysis.

First, the historic pattern has been for the U.S. government to invest in technology and production to address a pressing problem of national security. Thus, in examining potential government investments in innovation, a problem-focused investment strategy has historically shown to overcome not only the normative disagreements about the role of government support but also is more likely to provide the requisite support that enables new producers to create viable businesses.

The businesses that arise from addressing a problem of national importance through public funds follow one of two evolutionary paths. In one, the newly established innovative business expands into new non-governmental applications (commercial mass markets) by leveraging its existing infrastructure and leveraging its economies of scale. The other alternative is that the government-specific technology cannot or should not find a successful alternative market (for example, nuclear weapons) and remains captive to government sustainment. In previous years, investments targeted solutions to national problems and generated basic technologies for such disruptive technologies as semiconductors, aerospace, the internet preceded commercial markets. In contrast the present paradigm to develop solutions to government problems is to examine commercial products first and look for custom solutions only as a last resort.[8]

Secondly, governments worldwide have achieved consensus for funding innovation in two selected areas. The first area for public support is pre-competitive research. In pre-competitive research, public funds are required because such research does not provide an identifiable return on investment for commercial concerns competing in the global marketplace. The second acceptable area for public support is investments for incremental innovation,[9] often at universities and often in partnership with existing commercial concerns, which already have means of production, mass markets, and existing distribution channels.

Finally, we note there is a long-term danger that arises from the lack of a coherent national policy. Historically, it is instructive to note that at the 22nd Party Congress, Nikita Khrushchev direct the Soviets to outstrip the U.S. in coal, steel, cement, fertilizers, tractors, and lathes. By 1981, the Soviets had surpassed the U.S. those measures of a mid-20th Century industrial economy by investing in existing technologies. However, the U.S. won the Cold war with an economy based on the radical innovations of silicon, plastics, and world trade.[10] The moral is lack of consensus on investment strategies and the present focus solely on commercial markets may have severe long-term consequences for competitiveness as well as for national security.

It is our hope that explicit awareness of the steps required to convert concept into fielded innovation can guide the policy debate about the role of public funding for radical innovation. We feel that the approaches most likely to succeed in identifying appropriate areas and means of support for the radical innovations will be those that are based on an appreciation of those steps requisite to developing and sustaining a business enterprise.

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[7] See, for example, Andrew Grove "How to Make an American Job" available at: http://www.bloomberg.com/news/print/2010-07-01/how-to-make-an-american-job-before-it-s-too-late-andy-grove.html

[8] See, for example, http://www.defense.gov/speeches/speech.aspx?speechid=1003

[9] Augusto de Albuquerque, "From Microsystems to Smart Systems," COMS 2010

[10] Martin Walker, "America's Romance with the Future," Wilson Quarterly, Winter 2006, p. 22.