Discussion Papers on Entrepreneurship, Growth and Public Policy

MAX-PLANCK-GESELLSCHAFT

4604

Entrepreneurship and the Innovation Ecosystem Policy Lessons from the United States

by

Charles W. Wessner
U.S. National Academies and
Max Planck Institute for Research into Economic Systems

Number of Pages: 24

The *Papers on Entrepreneurship, Growth and Public Policy* are edited by the Group Entrepreneurship, Growth and Public Policy, MPI Jena.
For editorial correspondence,
please contact: egppapers@mpiew-jena.mpg.de

ISSN 1613-8333

Max Planck Institute for
Research into Economic Systems
Group Entrepreneurship, Growth and Public Policy
Kahlaische Str. 10
07745 Jena, Germany
Fax: ++49-3641-686710

CHAPTER 5:

ENTREPRENEURSHIP AND THE INNOVATION ECOSYSTEM POLICY LESSONS FROM THE UNITED STATES

Charles W. Wessner, PhD[1]
U. S. National Academies

1. INTRODUCTION

Germany and the United States face a common challenge in promoting innovation and entrepreneurship to maintain their leadership in global markets, with the economic growth and employment both societies seek. To this end, innovative policies at national and regional level are needed so that entrepreneurs—our local heroes—can be more successful in bringing the fruits of innovation to commercial reality. There is no prescribed formula to respond to this challenge. To foster the innovation process, public policies have to recognize and facilitate entrepreneurship within the multiple local contexts within which innovation takes place. For policies to be effective, they must focus less on aggregate input measures such as R&D percentages and more on the problems and incentives facing innovative entrepreneurs.

The United States is widely seen as one of the world's most innovative economies. Yet, the U.S. innovation system is not the well-oiled machine, smoothly generating innovation after innovation, as some European observers seem to believe. Indeed, many U.S. analysts doubt that the United States is maximizing its innovative potential. One reason for this perceived underperformance may be a lack of appropriate policy support, given that U.S. policymakers often do not understand the complex nature of the innovation process. They often regard new products simply as an outcome of the natural operation of the market, requiring little or no government role.

Even those familiar with the notion of a *National Innovation System* (NIS) often have a mechanistic (rather linear) view of the innovation process, understating the interactive processes actually taking place in the economy.[2] The NIS concept is often interpreted to imply that specific inputs into the innovation system can yield specific predicted results. This view is widespread in Europe as well, where there is a recognized need to generate more companies, more growth, and more employment.

The policy solution in Europe has often focused on pumping more money into basic research to fill the research deficit with the United States[3] and generate, by 2010, "the world's most competitive economy."[4] Funding basic research is of course essential for a modern industrial economy, but the added euros will not have their desired impact unless policymakers also address the incentives facing Europe's local heroes within their own cultures and political systems. Without focusing on the institutional framework and incentive for innovation, greater R&D inputs will not translate into the desired outputs of employment and growth (Wessner and Shivakumar 2002).

2. A NATIONAL INNOVATION ECOSYSTEM

A slightly different approach, but one that captures important nuance, is to understand the economy as a national innovation *ecosystem.* This approach can help us understand, first, that the system is not fixed but evolutionary, growing and evolving according to new needs and new circumstances and, second, that this system is susceptible to change as a result of new policy initiatives. The ecosystems approach highlights the complex *inter-linkages* among a variety of participants in an innovation economy (including individual entrepreneurs, as well as corporate actors such as large businesses and universities) and the importance of the *incentives* the various actors encounter as they push towards an "innovation friendly environment." Innovation, like regional competitiveness, will not be achieved by fiat but rather through a combination of public and private initiatives.

As we will see in the U.S. context below, an ecosystem approach to innovation policy draws special attention to the role of small businesses in economic growth and job creation. The analysis below should help dispel common myths about the nature of innovation and the positive role that government support can play. We also describe how innovative policies, like the U.S. Small Business Innovation Research (SBIR) program, have helped motivate new entrepreneurship and have helped entrepreneurs bridge the gap in early-stage technology funding, bringing as a result new, wealth creating ideas to commercial reality. The ecosystem concept is useful because it highlights both the changes that take place in an innovation system and the need for policy innovations to address the complex challenges that Germany and the United States face in promoting their local heroes in the global village.

3. SMALL BUSINESS AND INNOVATION

It is now widely recognized that small businesses are a key driver of the United States economy.[5] They have generated sixty to eighty percent of net new jobs annually over the past decade and employ nearly forty percent of the United States' science and engineering workforce (Small Business Administration 2004). These scientists and engineers, working in small businesses, produce fourteen times more patents than their counterparts in large patenting firms. These patents, moreover, are of high quality and are twice as likely to be cited.[6]

Another characteristic of small firms is that relatively small increments of investments can have a very high payoff in terms of long-term growth (Branscomb and Auerswald 2001). Such investments in early-stage technology development refresh the nation's economic foundations by transforming its science and engineering knowledge into valuable, sometimes "game-changing" innovations. In many cases, critical early investments in demonstration projects, new technology development, and R&D have been provided by the U.S. government. This important government role is not widely recognized in the United States. Yet as tab. 5.1 below illustrates, many major innovations were made possible through government funding for early-stage technology development.

Tab. 5.1: Precedents for public role in commercialization of science in the U.S.

- 1798 – Grant to Eli Whitney to produce muskets with interchangeable parts, founds first machine tool industry.
- 1842 – Samuel Morse receives award to demonstrate feasibility of telegraph.
- 1903 – Wright Brothers fly, fulfilling the terms of an Army contract.
- 1915 – National Advisory Committee for Aeronautics plays an instrumental role in the rapid advance in commercial and military aircraft technology.
- 1919 – Radio manufacturing (RCA) founded on the initiative (Equity and Board Membership) of the U.S. Navy with commercial and military rationales.
- 1940s, '50s, and '60s – Government investments in Jet Aircraft, Semiconductors, Computers, Satellites, Nuclear Energy lay the "Foundations of the Modern Economy" (Cohen and Noll 1992).
- 1969-1990s – Government investments create the forerunners of the Internet (Arpanet) and build the Global Positioning System.
- Today: Current investments are mainly found in genomic and biomedical research, and advanced computing and new materials, (e.g., nanotechnology initiatives).

Despite these and other achievements, many in the United States argue that it is "un-American" to intervene in the market by providing public support for private companies. This view suggests that in the United States, as elsewhere, the messy realities of the innovation process are often disconnected from how our political establishments and many influential people think about it. This disconnect has led to (what might be gently referred to as) curious ambiguities in public policy. For example, despite having noted the contributions of small firms to the economy, small firms are penalized, in effect, for their contributions through disproportionately large regulatory burdens. For instance, small firms (those with less than twenty employees) spend sixty percent more per employee than large firms to comply with federal regulations (Crain and Hopkins 2001).

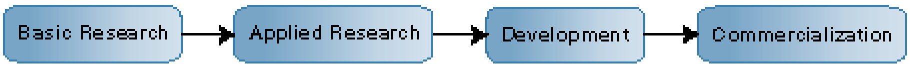
Another example of this ambiguity concerns the frequent disputes over public support for early-stage technology development. New firms struggle for adequate funding, with over eighty percent of them relying on various forms of formal credit. Given the increase in public welfare that arises from successful innovation, early stage funding for innovation by the government would appear to be in the national interest—and, as tab. 5.1 shows, it has frequently been so. The Advanced Technology Program (ATP), a well-designed but modestly funded merit based federal initiative, fulfills just this role. Over the years, it has developed an impressive track record of support for new technology development and commercialization, ranging from fuel cells to proteomics to medical diagnostics. In fact, ATP has been given very high marks by the National Academies and has been cited internationally as a best practice model (National Research Council 2001).

Yet the House of Representatives has called for the elimination of the program every year since 1996. These calls are normally based on the argument that the government should not “pick winners and losers.” In the American lexicon, this means that government should not “intervene” in the economy. Opponents of the program assume that markets work well and that good ideas will therefore also be funded by the market.[7] Such myths about the innovation system are widely held both in the U.S. and Europe. Understanding the underlying reality behind these myths is important for effective policymaking on both sides of the Atlantic.

4. MYTHS AND REALITIES ABOUT GOVERNMENT SUPPORT OF INDUSTRY R&D

Myths concerning government support for industry research and development often arise from a simple mechanistic understanding of, what is in reality, a complex innovation ecosystem. The linear model of innovation (See fig. 5.1) is as pervasive as it is erroneous. It creates the impression that increasing public and private investments in research will automatically result in greater commercialization, strengthening, in turn, national competitiveness in global markets. While its appeal lies in the elegance of its exposition, it is easy to forget that this simple model severely understates the complex interactions that actually take place within the innovation process.[8]

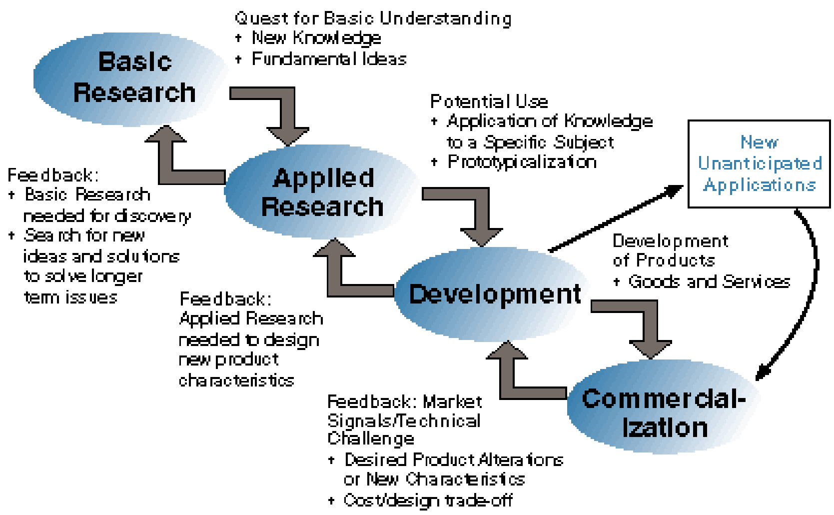
Fig 5.1: The myth of the linear model of innovation



In the real world of research and innovation, distinctions between basic and applied research are rarely clear cut. (As Alan Bromley, the first President Bush's Science Advisor famously remarked, whether the work is considered basic or applied frequently depends on the researcher's intent at a given moment in time.) Many discoveries have a serendipitous element. Much learning occurs by trial and error. Many good ideas simply do not make it to the market place. The process from discovery to innovation to commercialization involves consecutive challenges and market signals that can often be indistinct or even absent.

A more sophisticated representation of the innovation process (though still, it must be emphasized, a model) includes feedback loops through which learning occurs. These loops—portrayed in fig. 5.2—suggest that technological breakthroughs may proceed, as well as stem from, basic research. This representation questions—though does not preclude—the implicit primacy of curiosity driven research, unrelated to markets or social needs. In the real world, many questions worthy of research are in fact derived from industry or social needs (Stokes 1997).[9]

Fig. 5.2: A non-linear model of innovation



4.1 Is There a 3% Solution?

This complexity of innovation means that numerical targets for research expenditures must be accompanied by policies and actions that focus on the incentives and intermediating institutions designed to focus researchers' attention more on problems needing science-based solutions rather than on science for its own sake.

In the understandable desire to encourage innovation, and demonstrate a commitment to competitiveness, the European Council's Barcelona Declaration set an ambitious objective of increasing the Union's global research expenditure to approach three percent of Gross Domestic Product by 2010 with the specific goal of achieving greater firm growth and innovation.[10] Yet questions about the efficacy of this approach are widespread. One difficulty is that some European countries, like Sweden, already have high R&D expenditure as a percent of GDP with very limited *new* firm growth or innovation (outside large firms) to show for the high R&D expenditures. The case of Sweden strongly suggests that there is no correlation, must less causality, between levels of input expenditures on R&D and desired levels of innovation-led growth (Henrekson and Rosenberg 2001).

It is important to keep in mind that Europe is one of the world's foremost centers for research. The quality of European research is not in question. The problem facing many European countries relates more to how they may capitalize on the *existing* R&D investments. While the three percent target, described by some as a political goal, has the virtue of focusing public attention on the need for innovation, its actual import has been limited at best. The practical challenge is for policymakers to focus on creating better incentives for researchers in companies and universities to encourage them to convert their ideas into innovations and, eventually, into promising products for the global market.[11] Promoting a better understanding among policymakers of the realities of the innovation process is a major and necessary step in facilitating innovation while providing the opportunity to generate measurable returns on incremental R&D investments.

4.2 They Myth of Military Spin-Offs

In the same vein, understanding the sources of U.S. strength in innovation is important, especially if policy prescriptions for Europe are to draw from U.S. practice. One aspect of the U.S. innovation system that seems particularly susceptible to misinterpretation is the role of U.S. defense spending. There is, of course, a commonly held myth in Europe that U.S. defense research and procurement directly funds civilian technologies.

The myth appears to be rooted in selected examples in history that, to the extent they were accurate, no longer hold useful insights concerning the operation of the U.S. innovation system. Military support for aircraft, for example, is often cited as evidence for military-civilian spin-off. While it is true that defense procurement initiated research that helped Boeing develop the 707 (and to a lesser extent the 747) commercial aircraft, this happened over 50 years ago and in the context of an intense threat to European and U.S. security. These and other investments helped achieve a key U.S. policy goal (i.e. a credible capacity to transport troops and equipment rapidly), thereby making the need to do so less likely. These investments provided massive positive spillovers by deterring conflict and also fueling the boom in tourism that continues to enrich the lives of travelers and hosts around the world

It is important to understand that this spin-off model is less and less relevant to U.S. innovation. Indeed, many U.S. analysts argue that in today's world, U.S. defense related investments tend at best to yield only modest civilian benefits. For example, the hugely expensive development of Stealth technology for aircraft appears to have no foreseeable civilian market even though it provides significant military advantage. Extremely reputable U.S. analysts have argued that the requirements of military secrecy, military specifications, and long lead times associated with Pentagon procurement all act to slow the diffusion of new defense related technologies.[12]

The problem for the American defense establishment, moreover, is that the procurement-based innovation system no longer works well. Many argue that U.S. defense programs desperately need "spin in"—that is the ability to draw technologies rapidly from the commercial sector—a process that is impeded by a cumbersome procurement system that tends to protect a de facto oligopoly of established companies.[13]

The potential for military spin-off in the United States is also limited in part because the scale of the U.S. defense industrial sector has shrunk significantly following the end of the cold war, with the number of major U.S. defense contractors down from fifteen to five. To put this in perspective, consider that Intel Corporation is today valued at a hundred and fifty billion dollars—larger than the top three defense groups combined. This scaling-down means that the impact of defense R&D expenditures in the United States has a more modest impact on civilian innovation than commonly believed in Europe, and generally hoped for in the United States. Belief in this spin-off model can have negative consequences if it prompts additional budget support for defense R&D—support that is unlikely to yield the expected pay-offs in innovative civilian technologies and GDP growth.

4.3 The Myth of Perfect Markets

If some Europeans closely hold on to their belief that U.S. defense technology converts seamlessly to new commercial products, Americans themselves have deeply held myths about how their economy produces innovation. A common American myth is that "if it's a good idea, the market will fund it." In reality there is no such thing as "the market." Unlike the market model found in introductory economics texts, real world markets always operate within specific rules and conventions that lend unique characteristics to particular markets, and most markets suffer from seriously imperfect information.

Indeed, the problem of imperfect capital markets is particularly challenging for fledgling entrepreneurs. The knowledge that an entrepreneur has about his or her product may not be fully appreciated by potential customers—a phenomenon that economists call *asymmetric information*. This asymmetry can make it hard for small firms to obtain funding for new ideas because, as Michael Spence a recent winner of the Nobel Prize points out, new ideas are inherently hard to understand.[14] Few investors in the 1980's, for example, understood Bill Gates vision for Microsoft.

Box 1: Why US R&D spending on defense does not spill-over into civilian technologies

A recent study by PREST's Andrew James for the European Commission underscores the limitations of U.S. defense spending to the competitiveness of American commercial technologies. While the paper seems designed to support the view that the U.S. defense R&D spending contributes to U.S. competitiveness, to his credit, James nonetheless documents the concerns of U.S. analysts who argue that role of defense R&D is seriously overstated.

- First, given that the bulk of the RDT&E[a)] budget remains directed at development funding of traditional platforms (such as of combat aircraft) there are limited opportunities for civilian spin-offs—such as from heavy investments in stealth technologies noted earlier.
- Second, U.S. analysts question whether current funding for R&D is the right R&D for economic growth. U.S. analysts note that federal R&D funding has skewed in recent years towards the life sciences. Overall U.S. spending for R&D appears high because of growth in funding for Defense development and for Homeland Security development, while the major federal sponsors of physical sciences and environmental sciences have seen budget stagnation, real cuts, or at best modest growth. The affected agencies would include the Department of Energy Office of Science, Department of Defense S&T programs, NASA, NSF, the National Oceanographic and Atmospheric Administration, the Department of Interior, and the National Institute of Standards and Technology.
- Third, "the premise of spending money on defense R&D in the hope of gaining spin-off benefits is an ineffective policy at best. While there are some spin-offs, US analysts point out that this is hardly an efficient means of enhancing commercial competitiveness. The bulk of defense R&D spending remains focused on engineering development, testing, and evaluation where the prospects of spin-off benefits are relatively limited."

Source: James 2004

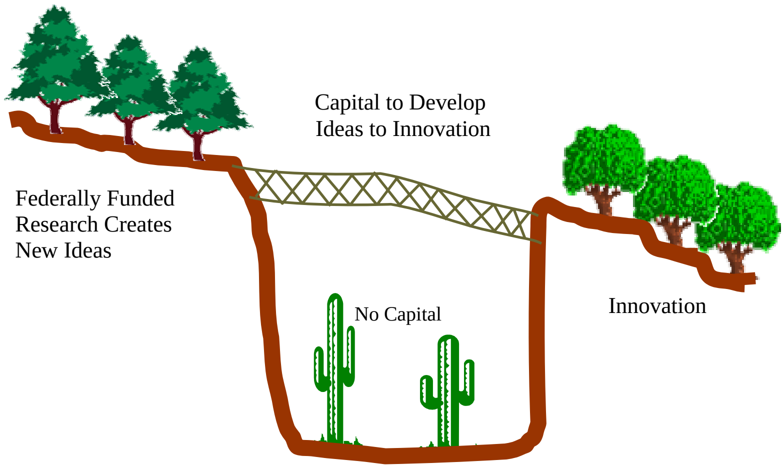
[a)] Research, Development, Testing and Evaluation. Heavy expenditure takes place in the latter two phases.

Market entry is thus a challenge for new entrepreneurs with new ideas for a potentially disruptive product. These entrepreneurs tend to be unfamiliar with government regulations and procurement procedures, and more broadly may be unacquainted with commercial accounting and business practices. Many small firms are therefore at a disadvantage vis-à-vis incumbents in the defense procurement process, and face especially high challenges with regard to finance.[15]

Another hurdle for entrepreneurs is *the leakage of new knowledge* that escapes the boundaries of firms and intellectual property protection. The creator of new knowledge can seldom fully capture the economic value of that knowledge for his or her own firm. This spillover can inhibit investment in promising technologies for large and small firms—though it is especially important for small firms focused on a promising product or process (Mansfield 1986).

The challenge of incomplete and insufficient information for investors and the problem for entrepreneurs of moving quickly enough to capture a sufficient return on "leaky" investments pose substantial obstacles for new firms seeking capital. The difficulty of attracting investors to support an imperfectly understood, as yet-to-be-developed innovation is especially daunting. Indeed, the term, *Valley of Death* has come to describe the period of transition when a developing technology is deemed promising, but too new to validate its commercial potential and thereby attract the capital necessary for its development[16] (see fig. 5.3). This simple image of the "Valley of Death" captures an important point, namely that technological value does not lead inevitably to commercialization. Many good ideas perish on the way to the market.

Fig.5.3: The valley of death

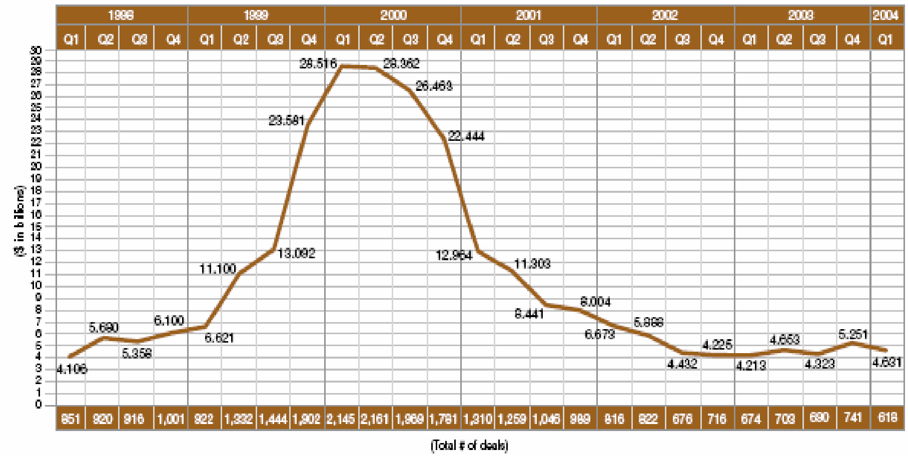


4.4 The Myth of U.S. Venture Capital Markets

A related myth is that the U.S. venture capital markets are so broad and deep that there's no need for government awards. In reality venture capitalists not only have limited information on new firms, as we have seen, but are also prone to herding tendencies, as witnessed in the recent dot.com boom and bust (Jacobs 2002 : 973).

Venture capitalists also, quite naturally, risk averse. Their goal, after all, is not to develop the nation's economy but to earn significant returns for their investors.[17] Accordingly, they tend to focus on later stages of technology development, because there is more information at this stage in the process about the commercial prospects of the innovation (and hence less risk to their investment.) And the amount of venture capital made available varies enormously, depending in no small part on the health of the stock market, which is the normal outlet for Initial Public Offerings where venture capitalists recoup their fund's investments. As fig. 5.4 below shows, venture capital fundraising and investment collapsed because the opportunities to harvest a private equity investment through Initial Public Offerings closed following the dramatic stock market declines of March 2000 (Megginson 2004).

Fig.5.4: Total equity investments into venture backed companies



Source: PricewaterhouseCoopers et al 2004: 1

Another frequently overlooked limitation to the contribution of venture capital is that the average size of venture capital investments has gone up. Because of their reward structure, most venture firms find it uneconomical to fund and monitor small investments (Lerner 1999). The problem is that most small companies do not need and/or do not qualify for sums on the order of $6 million. Small companies more often require funds in the range of $500.000 to $1.5 million. For these reasons, there is frequently no venture capital solution to meet the needs of new technology firms. The realities behind the venture capital myth, as that of other myths, require public policies that support entrepreneurship and encourage or provide seed funding for new firms.

5. U.S. POLICIES FOR INNOVATION LED GROWTH

What is often left out of European discussion of the U.S. innovation system are its systemic aspects—i.e., the environment for innovation. In the United States, the environment for innovation is shaped by policies concerning areas such as taxation, capital markets, intellectual property, as well as a host of regulations—often critical for new firms—concerning market entry, labor standards, and of course bankruptcy. Such policies and regulations define the risk-reward ratio for aspiring entrepreneurs. Together, they condition the willingness of entrepreneurs to take on the risk of firm creation. They can also condition the willingness of investors to support entrepreneurs as they move an idea from the laboratory to the marketplace. The generally supportive nature of these policies (buttressed by accommodating social and cultural attitudes) is one of the defining features of the U.S. innovation system.[18]

Tab. 5.2: Policy incentives for local heroes

- Innovation grants provide seed capital for entrepreneurs to start new firms—e.g. SBIR
- Competitively reviewed awards create information for markets, encouraging private capital investment in early-stage development—e.g., SBIR and ATP
- Intellectual property rights encourage invention by securing the fruits of invention
- Non-confiscatory tax policies preserve the rewards of entrepreneurship, and hence motivate entrepreneurship
- Labor flexibility provides firms the confidence to hire new workers—firms that can't fire won't hire.
- Gentle bankruptcy laws that enable entrepreneurs to assume the risk of a start-up without betting their homes and their futures.

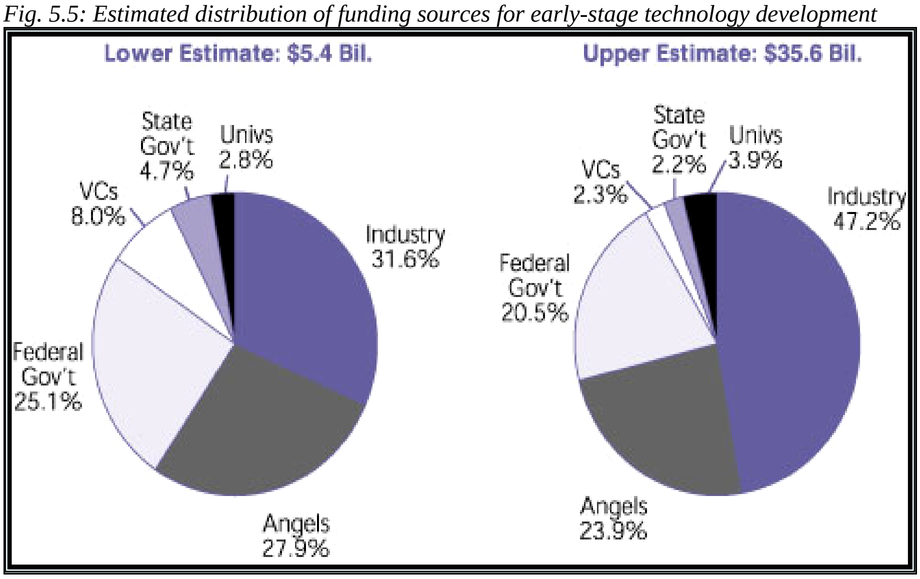
5.1 Multiple Sources of Funding

Funding for innovation is another important component of U.S. innovation policy. The funding is substantial if limited in relation to the economy as a whole, and the sources of finance are quite diverse. Although business angels and venture capital firms, along with industry, state governments, and universities provide funding for some aspects of early stage technology development, the federal role seems to be larger than is generally thought. Recent research by Branscomb and Auerswald estimated that the federal government provides between 20 to 25 percent of all funds for early stage technology development—a substantial role by any measure and one surprising to Americans in its dimensions (see fig. 5.5).[19]

This contribution is rendered more significant in that competitive government awards address segments of the innovation cycle that private investors often find too risky. Because technology-based firms are a significant source of innovation and competitive advantage for the United States, it is important to improve our understanding of the role public-private partnerships policies—in this case, innovation awards—play in encouraging small-firm growth in the United States (National Research Council 2002).

The availability of early stage financing and its interaction with other elements of the U.S. innovation process are the focus of growing analytical efforts.[20] As we examine below, the Small Business Innovation Research Program (SBIR) is the largest example of the government's public-private partnership efforts to draw on the inventiveness of small, high-technology firms though competitive innovation awards. The potential of SBIR in this regard underscores the need to understand how it strengthens the nation's innovation ecosystem.

Fig. 5.5: Estimated distribution of funding sources for early-stage technology development



Source: Branscomb and Auerswald 2002: 23

6. THE SMALL BUSINESS INNOVATION RESEARCH PROGRAM (SBIR)

Created in 1982 and renewed in 1992 and 2001, SBIR requires agencies with an extramural research and development budget of more than $100 million to set aside 2.5 percent of this budget for innovation awards to small businesses. The program is structured in three phases:

- Phase I is essentially a feasibility study in which award winners undertake a limited amount of research aimed at establishing an idea's scientific and commercial promise. Today, the legislation anticipates Phase I grants as high as $100.000.[21] The program is highly competitive, with less than 15 percent of the applicants receiving awards.
- Phase II grants are larger—normally $750.000—and fund more extensive R&D to further develop the scientific and technical merit and the feasibility of research ideas; about half of the Phase I awardees receive Phase II funding.
- Phase III. This phase normally does not involve SBIR funds, but is the stage at which grant recipients should be obtaining additional funds either from a procurement program at the agency that made the award, from private investors, or from the capital markets. The objective of this phase is to move the technology to the prototype stage and into the

commercial marketplace or government procurement, depending on the product.

Phase III of the program is often fraught with difficulty for new firms. In practice, agencies have developed different approaches to facilitating this transition to commercial viability; not least among them are additional SBIR awards.[22] Some firms with more experience with the program have become skilled in obtaining additional awards. Previous NRC research has shown that different firms have quite different objectives in applying to the program. Some seek to demonstrate the potential of promising research. Others seek to fulfill agency research requirements on a cost-effective basis. Still others seek a certification of quality (and the investments that can come from such recognition) as they push science-based products towards commercialization (Cramer 2000).

Features that make SBIR grants attractive from the firm's perspective include the fact that there is no dilution of ownership or repayment required. Importantly, grant recipients retain rights to intellectual property developed using the SBIR award, with no royalties owed to the government. The government retains royalty free use for a period, but this is very rarely exercised. Selection to receive SBIR grants also tend to confer a certification effect—a signal to private investors of the technical and commercial promise of the technology.[23]

6.1 Government Goals

From the perspective of the government, the SBIR program helps achieve agency missions as well as encourage knowledge-based economic growth (National Research Council 2004). By providing a bridge between small companies and the federal agencies, especially for procurement, SBIR serves as a catalyst for the development of new ideas and new technologies to meet federal missions in health, transport, the environment, and defense. It also provides a bridge between universities and the marketplace, thereby encouraging local and regional growth. Finally, by addressing gaps in early-stage funding for promising technologies, the program helps the nation capitalize on its substantial investments in research and development. While SBIR operations and accomplishments are sometimes discussed in general terms, the actual implementation of the program is carried out in agencies with quite distinct missions and interests. There is, therefore, significant variation in objectives and mechanisms.

Today, eleven agencies and departments grant SBIR awards totaling some $2 billion annually to support a wide variety of federal missions. While large, overall, SBIR is decentralized in terms of the agencies responsible for its implementation. This decentralization reflects the diversity of program goals and the variety of award recipients covered under

SBIR. For example, SBIR awards by the National Institutes of Health (NIH) are often—although not exclusively— directed towards initiating long-term drug development. Those awarded by the Department of Defense (DoD) by comparison, are often directed towards shorter-term product acquisition and defense-only applications. It is important to note that there is important variation across and within agencies. For example, sub-units of large agencies such as NIH and DoD pursue their own distinctive organizational goals. Within DoD alone, these vary from outfitting Special Forces to supply management to the development of vaccines to protect troops to improving telecommunications. Reflecting this mission diversity, each agency typically also has its own manner of initiating solicitations, choosing awardees, and screening for applicants.

Tab.5.3: Contributions of SBIR concept

- ✓ Catalyzes the development of new ideas and new technologies
- ✓ Helps create new firms to capitalizes on substantial U.S. R&D investments
- ✓ Addresses gaps in early-stage funding for promising technologies
- ✓ Certification Effect—Government endorsement of technical quality acts as a positive signal, attracting private investment
- ✓ Provides a bridge between small companies and government agencies, especially for procurement
- ✓ Contributes new methods and new technologies to agency missions

Key among the contributions of the SBIR concept (summarized in tab. 5.3 above) is its certification effect. The fact the government is giving an entrepreneur an award based on a two-phase review of technical merits and commercial potential is a signal of quality that attracts private capitalists seeking to reduce the uncertainties associated with early-stage finance. This certification effect contradicts another common policy myth that innovation awards “crowd-out” private capital. Indeed, recent empirical research by Paul David, Bronwyn Hall, and Andrew Toole demonstrates that there is only, at best, equivocal empirical support for the contention that private capital is crowded out (David, Hall and Toole 1999).

Indeed, recent research commissioned by the National Academies has found that competitive innovation awards can “crowd-in” investment capital because of the halo effect of the government endorsement (Feldman and Kelley 2001). In sum, programs like SBIR can stimulate the commercial application of scientific research and help bridge the Valley of Death by providing seed capital and validation for private investors. As we see below, public-private partnerships like SBIR can also act as a catalyst for cooperation, linking university researchers, companies, and research institutions to bring new ideas to market.

7 THE ENABLING ROLE OF UNIVERSITIES

Research universities are a key component of the U.S. innovation ecosystem. Their role as focal points in the innovation system has evolved tremendously over the last twenty years. More than ever before, industry depends on university research for new ideas for improved products and processes, while university researchers frequently draw ideas from commercial trends to explore new veins of scientific inquiry.

The university role in the regional economy has also undergone significant change. Universities are increasingly recognized not only as centers of learning but also as poles of regional growth and employment. It is important to note that the distribution of university contributions to local economies is by no means even. There is significant variation across states and regions in the United States, with some universities such as MIT and Stanford now recognized as global centers of innovation, while others are much less active and less effective in commercializing new technologies. The contribution of U.S. universities to innovation and growth is, nevertheless, widespread. In Pittsburgh, Pennsylvania, for example, the University of Pittsburgh and Carnegie-Mellon University have become the largest employers in the region and are spurring the creation of innovative new firms, helping to replace the reliance of the regional economy on the steel industry.[24]

Box 2: Universities as engines of economic growth

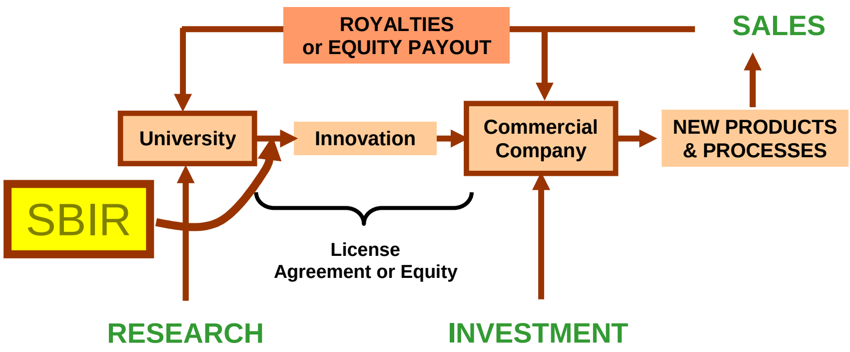
> "To suggest that, somehow, universities are not and should not be engines of economic growth is missing the central point of how our economy grows and how we create jobs."
>
> Robert Birgeneau, Chancellor, UC Berkeley
> Quoted on NPR Morning Edition, Date: 08-09-04

The growth of the U.S. biotech industry to its position of world leadership is associated by some with the close links between American universities and industry. This type of cooperation is increasingly found in Germany as well. The University of Munich, for example, spun off a series of private companies during the dotcom boom, suggesting that with the right leadership and incentives, German universities can contribute to the creation of innovative new companies as well (Washburn 2000: 9).

Universities, in turn, also benefit from their connection to their communities. Encouraged by the Bayh-Dole University and Small Business Patent Act—a 1980 federal law that permits government grantees and contractors to retain title to federally funded inventions and encourages universities to license inventions to industry—universities are now encouraged to license technologies for commercial exploitation.[25] This, however, has, sometimes led to protracted disputes about patent valuations between inventors and investors. In order to better align the interests of universities with those of their licensees, universities are now taking equity positions with increasing frequency (Feldman, Feller, Bercovitz and Burton 2002). When the SBIR program was created in the early 1980s, universities strongly objected to the program, seeing it as a source of competition for federal R&D funds.

In the course of the decade of the 1990s, this perception of the program significantly evolved. In the commercialization-sensitive environment created by Bayh-Dole, SBIR awards were increasingly seen as a source of early-stage financial support for promising ideas.

Fig 5.6: How ideas are commercialized: transferring university technology to firms



Source: Adapted from C. Gabriel, Carnegie Mellon University

The role of SBIR in encouraging professors to found companies based on their research appears to be growing in importance.[26] Importantly, the availability of the awards and the fact that a professor can apply for an SBIR award without actually having a firm, encourages applications from academics who would not otherwise be likely to commercialize directly their own technologies. Initial National Academy of Sciences research has shown that SBIR awards directly cause the creation of new firms, with positive benefits in employment and growth for the local economy.[27]

Contrary to what one might expect, the awards generally do not seem to detract from the teaching role of the university professor. On the contrary, the real life application of research with the attendant recognition in academic, technical, and financial terms can serve as a source of inspiration for students to pursue the real-world applications of their studies. Similarly, well-constructed agreements can provide access to otherwise cost-prohibitive technological resources thus enhancing the relevance of the students' educational experience.[28] University innovation along with early-stage funding by the government have spurred the growth of many successful technology companies, promoting a positive symbiotic relationship between the university and the regional economy.[29]

8. COMMON CHALLENGES IN INNOVATION POLICY: THE NEED FOR CIVIC ENTREPRENEURS

Policymakers around the world are focused on the challenges of making their economies more innovative. Many face genuine obstacles in encouraging university-industry cooperation and other types of public-private partnerships for the development of new technologies. Policymakers in both Germany and the U.S. face a common challenge in capitalizing on the substantial investments in R&D made by their nations. This is especially true with regard to the commercialization of publicly-funded research and development.[30]

Can the lessons gained from the U.S. experience be adapted for Germany? There are certainly cultural differences between Germany and the United States, yet the claims by some of American exceptionalism seem unwarranted. Our view is that there is a great deal of quality research and that there are many potential entrepreneurs on both sides of the Atlantic. The issue is how to provide the necessary incentives on one hand and reduce bureaucratic and regulatory obstacles on the other.

The concept of the innovation ecosystem draws attention to the need for civic entrepreneurs willing to take the steps necessary to clear the path and generate opportunities for private entrepreneurs. Effective policies to promote innovation-led growth and employment will require the political flexibility to change institutions so that incentives facing individuals are more closely aligned with broader social goals of economic dynamism and the political choices it offers nations and communities.

9. LESSONS FROM THE SBIR PROGRAM

The SBIR program, an example of civic entrepreneurship, has evolved over its twenty year history to provide major incentives to potential and existing entrepreneurs in the Untied States, while enabling the government to achieve important social missions in the environment, transportation, defense, health, and space exploration more efficiently.[31] As one of the most effective U.S public-private partnerships, the SBIR program provides some important lessons for comparable initiatives in civic entrepreneurship in Germany and elsewhere:

- *Focus innovation programs on the individual entrepreneur*. After all, countries don't innovate; firms do. Industry initiation and management of projects is essential. Providing broad solicitations to attract a variety of approaches towards achieving a given government mission is one of the SBIR program's strengths.
- *Limiting the government's participation*. Ensuring that government funds are granted on a competitive basis, with real and transparent competitions, is essential. Requiring industry cost share, and limiting public commitments in funds and time are important to maintain the entrepreneur's commitment to a successful commercial outcome and to identifying technical failure early in the development cycle.
- *Improving markets by encouraging private initiative.* Government innovation awards such as SBIR do not replace the market. They can improve imperfect investment markets by creating new information about the quality of an innovation (through government and private review) and the commercial potential (by government interest and/or implicit endorsement) of the product. Another one of SBIR's major advantages is its bottom-up approach, relying on self-initiation by entrepreneurs with ideas for technologies applicable to government needs or commercial markets.
- *Match policies to market realities*. SBIR focuses on market processes—the environment where real entrepreneurs make real decisions—rather than on policy inputs—the realm of economists and their models of innovation. Without attention to market processes, more inputs into the innovation process (such as the European Commission's 3 percent solution for innovation-led growth) will not necessarily deliver better results.
- *Take advantage of Constructive Confusion*. While a harmonized policy looks well ordered from the policymaker's point of view, it often fails to make sense from the entrepreneur's perspective and can easily understate the diverse public needs and institutional processes. Policies that provide points of coordination for multiple and localized industry initiated efforts, by contrast, can exploit the richness of diversity in a nation's innovation ecosystem. A strength of the SBIR program is that it is administered flexibly, allowing the program to adapt to the various agency missions, scientific opportunities, and commercial imperatives. A centrally managed system with the attendant bureaucratic procedures and controls could well stifle the program.
- *Foster a culture for innovation.* Fostering a culture of innovation requires a change in the incentives facing entrepreneurs and others in

the innovation ecosystem. Encouraging more professors to start new companies to commercialize their research ideas, for example, will come about only when the university supports and rewards such behavior in one form or another. This need for a change in university culture is often easier to recognize than to effect. One way to address this is to encourage parallel research institutions that encourage and reward cooperation on research relevant to industry needs.

These lessons, while important, provide no one-size-fits-all solution; there is no American panacea for the innovation challenge facing European economies. Germany, however, recognizes the nature of its challenge, and Chancellor Schroeder's attention to the role innovation merits broad national support. As we have seen, SBIR can promote local heroes as part of a national strategy for realize greater returns on national investments in research while strengthening the research and regional growth so necessary for Germany's future.

NOTES

[1] The author would like to recognize the many important contributions of his colleague Dr. Sujai Shivakumar of the National Academies Board on Science, Technology, and Economic Policy to the preparation of this paper.

[2] The National Innovation System (NIS) approach concerns how knowledge is created, diffused, and used in an economy. In particular, the NIS research agenda focuses on complex mechanisms promoting knowledge distribution, national and regional policies, economic and knowledge infrastructures, and international linkages and comparisons. Richard Nelson has played a leading role in developing and disseminating the concept of a national innovation system (Nelson 1993).

[3] For example, see COM 2003, European Commission, DG Research. (Luxembourg). *Third European Report on Science and Technology Indicators* (www.cordis.lu/indicators).

[4] The 2010 goal is stated in the European Union's Lisbon Strategy. See http://europa.eu.int/comm/lisbon_strategy/index_en.html.

[5] Birch's work exercised major influence on the perception of the role of small firms. David Audretsch and Zoltan Acs have also pioneered research on the role of small firms in the economy (Acs and Audretsch 1990).

[6] Ibd.

[7] Although program proponents have so far saved the program, the yearly uncertainty over funding is not desirable, by any definition, for an R&D program requiring companies to prepare complex submissions to justify funding. The fact that applications have risen in recent years attests both to the value and perceived quality of ATP and to the dearth of alternate sources of early-stage funding.

[8] While, as the limiting case, the innovation process can be relatively simple, such examples are rarely found in the real-world.

[9] The complementarities between applied and basic research was persuasively argued in Stokes 1997.

[10] See European Council, Presidency Conclusions—Barcelona, 15 and 16 March 2002, SN100/1/02 REV 1, Page 20.

[11] Wessner and Shivakumar op cit. For the challenge of transforming ideas into innovations, see Branscomb and Auerswald, op. cit.

[12] Alic documented this phenomenon in 1992 (Alic 1992).

[13] This problem is succinctly described in a White Paper by Senator Lieberman's office. See "White Paper: Nation Security Aspects of the Global Migration of the U.S. Semiconductor Industry." Office of Senator Lieberman, June 2003, p. 1-2, http://lieberman.senate.gov/newsroom/whitepapers/semiconductor.pdf.

[14] The Nobel Committee cited Spence's contribution in highlighting the importance of market signals in the presence of information asymmetries. For his seminal paper on this topic, see Spence 1974.

[15] Innovators in large firms also face a similar problem, where multiple options, established hurdle rates, and technological and market uncertainties militate against even promising technologies. As noted by Dr. Bruce Griffing, the laboratory manager responsible for developing mammography diagnostic technology for General Electric noted, "*There is a valley of death for new technologies, even in the largest companies.*" (Griffing 2001). With regard to the challenges small firms face in obtaining funding, see Branscomb and Auerswald, *Taking Technical Risks*, op. cit. See also Josh Lerner, "Public Venture Capital," in National Research Council, *The Small Business Innovation Program: Challenges and Opportunities*, C. Wessner, ed. Washington, D.C.: National Academy Press, 1999.

[16] See Vernon J. Ehlers, *Unlocking Our Future: Toward a New National Science Policy, A Report to Congress by the House Committee on Science* (Washington, D.C.: GPO, 1998). Accessed at http://www.access.gpo.gov/congress/house/science/cp105-b/science105b.pdf.

[17] "The goal of venture capitalists is to make money for our fund investors – not to develop the economy." Personal communication with David Morgenthaler, founder Morgenthaler Ventures and past President of the National Venture Capital Association.

[18] See, for example, Nelson 1997.

[19] It is important to remember that these are estimates. The authors stress the "limitations inherent in the data and the magnitude of the extrapolations…" and urge that the findings be interpreted with caution. They note further that while the funding range presented for each category is large, these approximate estimates, nonetheless, provide "valuable insight into the overall scale and composition of early-stage technology development funding patterns and allow at least a preliminary comparison of the relative level of federal, state, and private investments." For further discussion of the approach and its limitations, see Branscomb and Auerswald 2002 : 20-24.

[20] The growth and subsequent contribution of venture capital have begun to attract the serious study needed to illuminate the dynamics of high-technology firm evolution. See for example, the work of Jeffrey Sohl and colleagues and the University of New Hampshire's Center for Venture Research, described at http://www.unh.edu/cvr.

[21] With the accord of the Small Business Administration, which plays an oversight role for the program, this amount can be higher in certain circumstances; e.g., drug development at NIH, and is often lower with smaller SBIR programs, e.g., EPA or the Department of Agriculture.

[22] NSF, for example, has what is called a Phase II-B program that allocates additional funding to help potentially promising technology develop further and attract private matching funds. As with venture-funded firms, Phase III is likely to include some mix of economically viable and non-viable products, ultimately to be determined by the relevant agency mission requirements or private markets.

[23] This certification effect was initially identified by Lerner 1999., "Public Venture Capital," in National Research Council, The Small Business Innovation Program: Challenges and Opportunities, C. Wessner, ed. Washington, D.C.: National Academy Press, 1999.

[24] See remarks by Christina Gabriel in National Research Council, *The Small Business Innovation Research Program, Program Diversity and Assessment Challenges*, op cit.

[25] David Mowery and Bhaven Sampath note that success in applying the Bayh-Dole concept more widely depends on the attention given to the structural differences in the educational systems of other nations. See Mowery and Sampath 2004. , "The Bayh-Dole Act of 1980 and University-Industry Technology Transfer: A Model for other OECD Governments?" in *Ivory Tower and Industrial Innovation: University-Industry Technology Transfer Before and After the Bayh Dole Act*, Palo Alto: Stanford University Press, 2004.

[26] This remains to be empirically determined, although there is substantial anecdotal evidence supporting this trend. For an illustrative case, see Audretsch et al. 2000.

[27] See National Research Council, *The Small Business Innovation Research Program, An assessment of the Department of Defense Fast Track Initiative*, op cit.

[28] Cooperation with private companies is not without risk and requires careful management; yet even controversial agreements like the 1998 Berkeley agreement with Novartis seemed to have provided significant benefits to the university with no loss to academic freedom. See Rausser, G.C.: Letter to the Editor of *Atlantic Monthly*, May 19, 2000. Accessed at www.cnr.berkeley.edu/pdf/dean_rausser/Atl_ltr_edt_5_2000.pdf.

[29] See Henderson and Smith 2002. It is important to reemphasize that not all universities have a commercialization culture, and among those that do, not all have a successful commercialization process. For a discussion of some of the reasons for this variation, see Siegel, Waldman and Link 2004.

[30] See the Opening Statement by House of Representatives Armed Services Committee Chairman Duncan Hunter concerning the lack of return on US R&D investments at the Committee Hearing on the Impact of Defense Offsets, held on 8 June 2004.

[31] The concept of early-stage financial support for high-risk technologies with commercial promise was first advanced by Roland Tibbetts at the National Science Foundation (NSF). As early as 1976, Mr. Tibbetts advocated that the NSF should increase the share of its funds going to small business. This civic entrepreneurship led ultimately to the establishment of the SBIR program. For an overview of the origins and history of the SBIR program, see Turner and Brown 1999.

REFERENCES

Acs, Z.J and Audretsch, D.B. (1990). *Innovation and Small Firms.* Cambridge, MA: MIT Press.

Alic, J. (1992). *Beyond Spinoff: Military and Civilian Technologies in a Changing World.* Boston: Harvard University Press.

Audretsch, D.B. et al. (2000). "Does the Small Business Innovation Research Program Foster Entrepreneurial Behavior? Evidence from Indiana." In National Research Council. *The Small Business Innovation Research Program, An Assessment of the Department of Defense Fast Track Initiative*, C. Wessner (ed.), Washington DC: National Academy Press.

Birch, D.L. (1981). "Who Creates Jobs?" *The Public Interest* 65: 3-14.

Branscomb, L.M. and Auerswald, P.E. (2001). *Taking Technical Risks: How Innovators, Managers, and Investors Manage Risk in High-Tech Innovations*. Cambridge MA: MIT Press.

Branscomb, L.M. and Auerswald, P.E. (2002). *Between Invention and Innovation, An Analysis of Funding for Early-Stage Technology Development.* Gaithersburg, MD: NIST GCR 02–841, November 2002.

Cohen, L.R. and Noll, R.G. (1991). *Technology Pork Barrel.* Washington DC: Brookings Institution Press, June 1991.

Crain, W.M. and Hopkins, T.D. (2001). "The Impact of Regulatory Costs on Small Firms." In U.S. Small Business Administration, Office of Advocacy, Research Summary 207, October 2001.

Cramer, R. (2000). "Patterns of Firm Participation in the Small Business Innovation Research Program in Southwestern and Mountain States." In National Research Council. *The Small Business Innovation Research Program, An Assessment of the Department of Defense Fast Track Initiative,* C. Wessner (ed.), Washington, D.C.: National Academy Press.

David, P.A., Hall, B.H. and Toole, A.A. (1999): *Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence.* In NBER Working Papers, No 7373.

Feldman, M. and Kelley, M.R. (2001): "Leveraging Research and Development: The impact of the Advanced Technology Program." In National Research Council. *The Advanced Technology Program, Assessing Outcomes,* C. Wessner (ed.), Washington, D.C.: National Academy Press.

Feldman, M., Feller, I., Bercovitz, J. and Burton, R. (2002). "Equity and the Technology Transfer Strategies of American Research Universities." *Management Science,* 48 (1).

Griffing, B. (2001). *Between Invention and Innovation, Mapping the Funding for Early Stage Technologies.* Carnegie Conference Center, Washington, DC., 25 January 2001.

Henderson, J.A. and Smith, J.J. (2002). *Academia, Industry, and the Bayh-Dole Act: An Implied Duty to Commercialize*. In White Paper, Center for the Integration of Medicine and Innovative Technology, Harvard University, October 2002.

Henrekson, M. and Rosenberg, N. (2001). "Designing Efficient Institutions for Science-Based Entrepreneurship: Lessons from the U.S. and Sweden." *Journal of Technology Transfer,* 26 (3).Jacobs, T. (2002). "Biotech Follows dot.com Boom and Bust." *Nature*, 20 (10).

James, A. (2004). *US Defence and R&D Spending: An Analysis of the Impacts.* Rapporteur's Report for the EURAB Working Group ERA Scope and Vision, PREST, University of Manchester, January 2004.

Lerner, J. (1999). "Public Venture Capital." In National Research Council. *The Small Business Innovation Program: Challenges and Opportunities.* C. Wessner (ed.), Washington, D.C.: National Academy Press.

Mansfield, E. (1986): "How Fast Does New Industrial Technology Leak Out?" *Journal of Industrial Economics* 34 (2): 217-224.

Megginson, W.L. (2004). "Towards a Global Model of Venture Capital?" *Journal of Applied and Corporate Finance* 16 (1) Winter 2004.

Mowery, D. and Sampath, B. (2004). "The Bayh-Dole Act of 1980 and University-Industry Technology Transfer: A Model for other OECD Governments?" In D. Mowery et al. *Ivory Tower and Industrial Innovation: University-Industry Technology Transfer Before and After the Bayh Dole Act*. Palo Alto: Stanford University Press.

National Research Council (2001). *The Advanced Technology Program, Assessing Outcomes.* C. Wessner (ed.), Washington DC: National Academy Press.

National Research Council (2002). *Government-Industry Partnerships for the Development of New Technologies, Summary Report.* C. Wessner (ed.), Washington, D.C.: National Academy Press.

National Research Council (2004). *The Small Business Innovation Research Program, Program Diversity and Assessment Challenges.* Washington DC: National Academies Press.

Nelson, R. (ed.) (1993). *National Innovation Systems*. New York: Oxford University Press.

PricewaterhouseCoopers, Thomson Venture Economics and National Venture Capital Association (2004). *Money Tree Survey-Q1 2004 Results U.S. Report*. February 2004: http://www.pwcmoneytree.com

Richard Nelson (ed.) (1997). *National Systems of Innovation*. New York: Oxford University Press.

Siegel, D., Waldman D. and Link, A. (2004). "Toward a Model of the Effective Transfer of Scientific Knowledge from Academicians to Practitioners: Qualitative Evidence from the Commercialization of University Technologies." *Journal of Engineering and Technology Management* 21 (1-2): 115-142.

Small Business Administration, Office of Advocacy (2004). *Small Business by the Numbers*. June 2004.

Spence, M. (1974). *Market Signaling: Informational Transfer in Hiring and Related Processes*. Cambridge: Harvard University Press.

Stokes, D. (1997). *Pasteur's Quadrant, Basic Science and Technological Innovation.* Washington DC: Brookings Institution.

Turner, J. and Brown, G. (1999). "The Federal Role in Small Business Research." *Issues in Science and Technology* Summer 1999: 51-58.

Washburn, J. (2000). "The Kept University." *The Atlantic Monthly* 1 March 2000.

Wessner, C.W. and Shivakumar, S.J. (2002). *The Role of Macro Targets and Micro Incentives in Europe's R&D Policy.* IPTS Report 69 (11).