2010

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Preprint of chapter published in*:*

Competing for Global Innovation Leadership: Innovation Systems and Policies in the USA, EU and Asia, Rainer Frietsch and Margot Schüller (Eds.), Fraunhofer IRB Verlag, Stuttgart, 2010, Chapter 2, pp. 5-29.

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2 The Innovation System and Innovation Policy in the United States

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2.1 Introduction

The US has a highly decentralized and diverse innovation system, involving multiple actors, including branches of federal and state governments, public agencies, universities, the private sector, and non-profit and intermediary organizations. The system combines a high-level of R&D (with basic research sponsored particularly by federal government agencies) and a strong orientation towards applications and the market. This chapter provides an overview of the US innovation system and policy including a discussion of the components and participants involved in the US innovation system and its trends in innovation governance. The focus of this chapter is primarily on innovation policies with a commercial orientation. Key aspects of US innovation policies are highlighted, beginning with a brief review of selected framework and indirect policies that influence innovation. Consideration is then given to direct innovation policies and policies to foster capabilities for innovation in the US. Regional initiatives, new national coordinated policy efforts, and systems for assessment and evaluation are also discussed.

2.2 The US Innovation System: Scale, Structure and Key Actors

The US system of innovation is distinguished by its large size, diversity, federal structure, and competitive orientation. The US innovation system is embedded in an economy that (in the latest annual GDP figures available before the impact of the 2009 credit crunch) reached $14.3 trillion (€11.0 trillion) in output in 2008.[1] US research and development (R&D) investment leads that of other countries in sheer magnitude, $340 billion (€261 billion) in R&D expenditures in 2006, or about one-third of the entire world's R&D. In that year, the US spent 2.6% of its GDP on R&D (National Science Board, 2008).

The US federal government provides support for innovation through infrastructure development and addresses framework measures such as the intellectual property regime, regulation of financial markets, and interstate commerce. The federal government also sponsors basic as well as mission-driven research targeted to the particular needs of executive agencies, with defense-related R&D accounting for more than half of all federal R&D spending. (American Association for the Advancement of Science, 2008) The federal government sponsored 28 percent of US R&D in 2003 while per-

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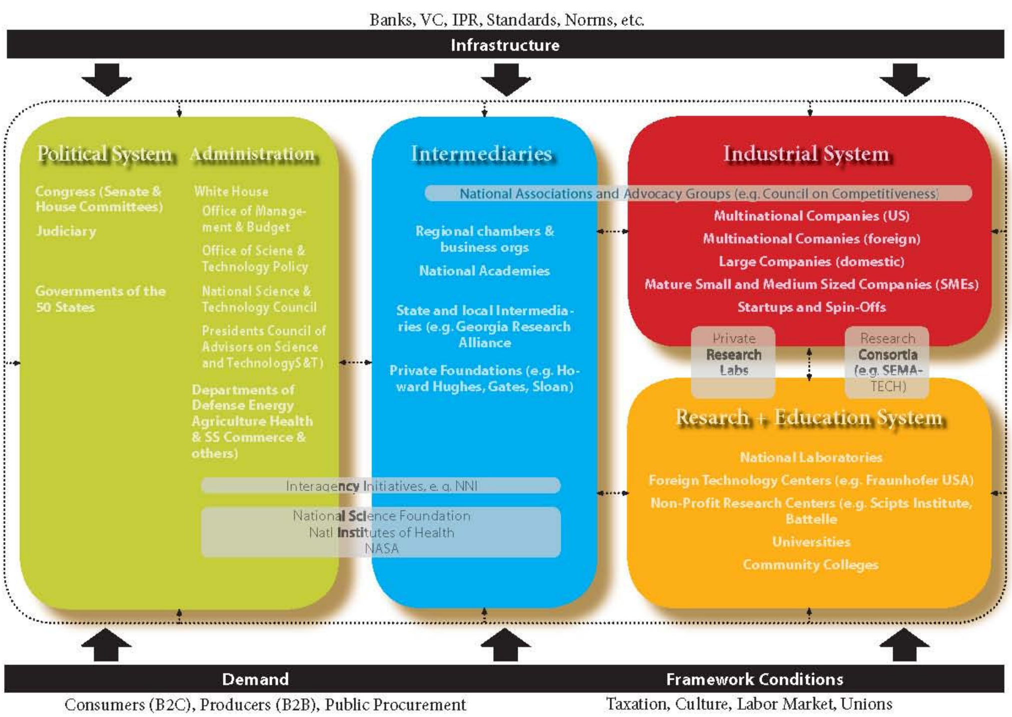
1 US Bureau of Economic Analysis, National Income and Product Accounts (http://www.bea.gov/, accessed May 26, 2009). Conversion from US$ to € (Euro) throughout this document is based on the average exchange rate for the first quarter of 2009 as reported by the European Central Bank ($US 1.3029 = €1.0000).

forming 11 percent (National Science Board, 2008). While the federal government does sponsor policy and programmatic initiatives directly related to innovation, more often federal support for innovation is indirect. In recent years, US state governments have increasingly engaged in innovation policy initiatives, which are typically direct and linked with state and regional business and economic development efforts.

Multiple and diverse actors from government, academia, the private sector, and non-profit organizations are involved in and motivate the US innovation system (see Figure 2-1). At the federal level, the innovation policy making system has multiple nodes. The White House and the US Office of Science and Technology Policy (OSTP) coordinate executive office initiatives. Headed by the Science Advisor to the President, OSTP provides advice on science and technology (S&T) policy, coordinates interagency R&D budgets, and addresses broad innovation problems and opportunities. The Presidents Council of Advisors on Science and Technology (PCAST) and the National Science and Technology Council (NTSC) are prominent among the expert committees that consider and provide advice on innovation-related issues. Also within the White House, the Office of Management and Budget (OMB) carries out annual budget reviews and performance assessments of agency programs.

Figure 2-1: Organizational Chart of the US National Innovation Governance System



Source: Fraunhofer ISI from Youtie and Shapira (2007)

The White House leads the executive branch which is comprised of agencies and departments with expressed missions. Many federal agencies have interests in innovation policy and programs. Particularly concerned with innovation is the US Department of Commerce (DoC). In turn, the DoC is responsible for agencies such as the US Patent and Trademark Office (USPTO), the National Institute of Standards and Technology (NIST), the Census Bureau, and the International Trade Administration.

The National Science Foundation (NSF) is primarily focused on sponsoring peer-reviewed basic research, but several of its programs (such as the Engineering Research Centers or the Industry-University Centers) incorporate industry orientations. Additionally, the NSF is a respected source of statistical information relevant for innovation policy making and sponsors research projects and initiatives on the analysis and measurement of innovation.

Other federal agencies with large R&D budgets, such as the National Institutes of Health or the Department of Defense, also have interests in issues related to commercialization, dual-use, and innovation related to their missions. Also important in innovation governance is the Small Business Administration, which coordinates one of the largest federal funding initiatives in support of innovation – the Small Business Innovation Research (SBIR) program, as well as its companion program the Small Business Technology Transfer program (STTR). SBIR/STTR is based on the allocation of a portion of the R&D budgets of 11 agencies with R&D budgets of $100 million (€76.8 million). Almost $2 billion (€1.5 billion) in SBIR/STTR funding was awarded to small and medium-sized businesses with fewer that 500 employees in 2005. (National Academies, 2007)

The US Congress has responsibilities and powers for introducing innovation-related legislation, authorizing and appropriating budgets, holding hearings and receiving testimony from stakeholders on innovation-related issues, and undertaking oversight. Comprised of the House of Representatives and the Senate, the Congress operates through a committee structure. The most significant committees for innovation issues are the House Committees on Small Business and Science and Technology, and Senate Committee on Commerce, Science, and Transportation. The Senate also confirms key executive appointments (for example, the Secretary of Commerce or the Director of NIST). The third major branch of government, the judicial system, has authority over legal and regulatory dispute resolution. The judicial system has become especially prominent in addressing innovation-related issues such as intellectual property disputes and legal issues around stem cell research. For example, the United States Court of Appeals for the Federal Circuit (established in 1982) has national jurisdiction over appeal cases related to patents, trademarks, international trade, and government contracts.

These government branches operate through a federal system of checks and balances. Each branch shares legal, policy, and funding powers. The federal government also shares powers with state and local governments. There are 50 US states and five additional equivalent legal jurisdictions, more than 3200 counties and similar subdivisions, in excess of 25000 cities and townships, and 952 metropolitan and micropolitan statistical areas (including 126 combined statistical areas representing major metropolitan agglomerations). State governments tend to be much more active in the innovation area than the federal government has been, primarily because there has traditionally been reluctance at the federal level to intervene in industrial policy, while state governments are closer to the needs of the particular industries that make up their regional economies. Many recent federal programs have had historic roots in long standing state and local innovation initiatives. This experimental and learning orientation of the states underlies their portrayal by Justice Louis Brandeis as "the laboratories of democracy." (Osborne, 1980)

Most innovation in the US is performed by private industry. Private industry undertook 71 percent of US R&D in 2006, of which 76 percent was development, 20 percent was applied research, and only 4 percent was basic research (National Science Board, 2008). Innovation encompasses more than these R&D measures; it also requires investment in product design, process and organizational changes, equipment and software, training, and marketing. There are no definitive estimates of all US investment in innovation, but it will be considerably greater than suggested by the R&D data. Innovation in private industry is undertaken by diverse sectors, including large multinational and national corporations, existing mature industries, and high-tech start-ups. Innovations can be disseminated to private sector firms through multiple methods, including through supply chains, licensing of intellectual property, and movement of human capital between companies and other types of institutions. There is a large and advanced venture capital sector available to support high-tech startups. The size of the sector has varied in keeping with the economic cycle. In the first quarter of 2007, US venture capital investments surpassed $7.5 billion (€5.8 billion); however, with the onset of the credit crunch, US venture capital investments had fallen to $3.0 billion (€2.3 billion) in the first quarter of 2009 (MoneyTree Report, 2009).

There are a number of intermediary and cross-boundary bridging organizations that play important roles in national innovation policy making. Among the most prominent are the Council on Competitiveness, which was established in the 1980s out of concerns about US manufacturing competitiveness relative to Japan and Germany, and the National Academies, which was created by Congress to provide advice in scientific and technological areas. These organizations undertake studies, organize workshops, and – most importantly – provide forums for various actors in the US innovation policymaking arena to come together, discuss issues, review performance, and consider new strategies. Private sector and university leaders play major roles, along with government agencies, in furnishing expertise and policy directions to these and other organizations. In addition, there are several institutions that facilitate learning and transferal of innovation practices across state government boundaries. In the S&T arena, the State Science and Technology Institute (SSTI) is a leading organization for fulfilling this knowledge sharing role. SSTI uses education, information provision, and research to serve as a wide-ranging resource for technology-based economic development practitioners.[2] At the local level, intermediary organizations – including chambers of commerce, public-private partnerships, and entrepreneurship forums – are active in most metropolitan areas, frequently with active agendas both to foster innovation in their areas and to influence city, state and federal innovation-related policies.

2 For more information on the State Science and Technology Institute, see http://www.ssti.org.

The role of educational infrastructure is important in the US innovation system, particularly at the tertiary level. Universities in the US are not subject to central chartering by the federal government. Rather, public universities are organized by states (often through large multi-campus state university systems), while private universities are typically established as non-profit organizations. In 2002, there were 2500 accredited postsecondary educational institutions in the US. However, only 126 of these are considered major research universities according to the Carnegie Classification of Academic Institutions (National Science Board, 2008). Universities perform 16 percent of US R&D but 55 percent of all basic research (most of which is funded by the federal government). They also educate students, with nearly 2 million receiving bachelors' degrees in 2002, 30 percent of which were in science and engineering disciplines. Universities have been involved in their local economics since the 19th century, including the state land grant universities established as a result of the Morrill Act of 1862. However, recently there has been a re-thinking and expansion of the role of universities as they are increasingly being looked to not just as sources for innovation but also as intermediaries to facilitate innovation processes, taking on technology transfer roles, becoming hubs for incubators, spin-offs, knowledge transfer, and state and local innovation policy. (Youtie and Shapira, 2008)

The system of national laboratories and federally funded R&D centers (FFRDCs) are important in the accomplishment of government-performed R&D. Nine federal agencies maintain FFRDCs; the US Department of Energy has the largest and most geographically distributed network of national laboratories, four of which are administered by private industry, four by nonprofit institutions, and eight by universities. In recent years, federal laboratories have placed greater emphasis on technology transfer and innovation, including through the establishment of technology transfer offices, encouragement of licensing, and incubators. The Federal Laboratory Consortium (FLC) is one of the national organizations that bring together federal laboratory representatives to consider innovation policy and programmatic topics.

Private non-profit foundations have traditionally been involved in providing funding for research activities. Roughly 10 percent of basic research support comes from foundations (National Science Board, 2008). Significantly, there is growing set of foundation initiatives that advance research and policy related to the innovation process itself. For example, the Ewing Marion Kauffman Foundation and the Alfred P. Sloan Foundation fund research into entrepreneurship and innovation processes and participate in policy-making activities in these areas. Another example is represented by the Annie E. Casey Foundation, which seeks to translate concepts and theories about innovation and economic development into programs for distressed communities.

These organizational structures and trends – marked by diversity and multiple layers and levels – form the framework for US innovation policy. The next sections present an overview of US innovation policy and how it has developed over time amidst a facilitative federal role. The encouragement of innovation through framework policies that address areas such as intellectual property, taxation forms, and government procurement is discussed. Additionally, we also consider a selection of policies, programs that provide direct assistance to business and industry, enhance capabilities for innovation through talent and infrastructure development, and foster coordination and regional innovation.

2.3 Innovation Policies in the US

US innovation policy at the national level is influenced by the philosophy that commercial innovation is primarily the purview of the private sector, aided by universities and government laboratories, not directed by the federal government itself. Under this perspective, the primary role of the national government is to facilitate the interactions of these organizations. While US state governments often take a more explicit role in development of innovation policy, this is not generally the case at the federal level. Moreover, innovation is typically at best a second-tier agenda item behind issues such as defense and homeland security, foreign policy, budget deficits, taxing, healthcare, and social security.

However, there have been periods when the federal government has pragmatically relaxed its non-interventionist orientation and become explicitly active in innovation policy. Much of the landmark legislation and programs relating to innovation have come from these more active periods (see Table 2-1). This was the case in the 1980s when the US federal government perceived the country was under significant competitive pressure (at that time principally from Japan). The early 1980s produced such historic legislation as the Bayh-Dole and Stevenson Wydler Acts which facilitated intellectual property protection for technology transfer, R&D tax credits, and the Small Business Innovation Research Program. In the late 1980s, technology extension, standardization, and industry-university research were fostered by the 1988 Omnibus Trade and Competitiveness Act. This legislation also resulted in a reorganization and new role in technology transfer and innovation for the US Department of Commerce. Legislation in the early 1990s extended and expanded these programs. Most recently, the mid-2000s saw renewed activity in innovation policy through the America COMPETES Act.

Table 2-1: Chronology of US Innovation-related Legislation: 1980s to 2000s

Year	Legislation	Highlights
1980	The University and Small Business Patent Procedure Act (Bayh–Dole Act), Public Law 96-517.	Permits universities and small business to obtain title to inventions funded by the federal government so as to license inventions.
1980	Stevenson–Wydler Technology Innovation Act, Public Law 96-480.	Requires federal laboratories to establish technology transfer offices and to set aside funds for technology transfer.
1981	Economic Recovery Tax Act, Public Law 9734	Establishes the Research & Experimentation tax credit as part of the U.S. Internal Revenue Code on a temporary basis
1982	Small Business Innovation Development Act, Public Law 97-219.	Requires federal agencies to provide special set aside funds for small business R&D. Was reauthorized in 2000 and 2008
1984	Cooperative Research Act, Public Law 98-462.	Eliminates tripling damages from anti-trust violations so that firms, universities and federal laboratories can engage in joint pre-competitive R&D.

Year	Legislation	Highlights
1986	Federal Technology Transfer Act of, Public Law 99-502.	Authorizes national laboratories to enter into cooperative R&D agreements (CRADAs) and negotiate licensing agreements.
1987	Executive Orders 12591 and 1218	Promotes commercialization of federal technology.
1988	Omnibus Trade and Competitiveness Act, Public Law 100-418.	Renames the National Bureau of Standards as the National Institute for Standards and Technology and expands its mission; establishes centers for transferring manufacturing technology.
1989	National Competitiveness Technology Transfer Act, Public Law 101-189.	Extends CRADA authority to all federal laboratories, including weapons labs.
1990	MEP Rule - Part 290, Title 15 of the Code of Federal Regulations, as published in the Federal Register September 17, 1990.	Creates the Manufacturing Extension Partnership (MEP) program.
1991	American Technology Preeminence Act, Public Law 102-245	Extends intellectual property exchange between participants in a CRADA
1991	Defense Authorization Act, Public Law 101-510.	Establishes model programs for linking defense laboratories with state and local government and small businesses; provides Defense Manufacturing Technology Plan.
1992	Defense Conversion, Reinvestment and Transition Act	Creates the Technology Reinvestment Project (TRP) which was administered by the Advanced Research Projects Agency to provide support for conversion of military products to commercial uses.
1992	Small Business Technology Transfer Act, Public Law 102-564	Establishes the Small Business Technology Transfer (STTR) programs to fund cooperative research involving small businesses, universities, and federal laboratories.
1993	Defense Authorization Act, Public Law 103-160.	Renames the Defense Advanced Research Projects Administration and authorizes dual-use technology programs for industrial application.
1995	National Technology Transfer Improvements Act ("The Morella Act") Public Law 104-113	Promotes commercialization from CRADAs by offering favorable intellectual property rights.
1998	Technology Administration Act, Public Law 105-309	Authorizes continued federal support for MEP.
1999	The American Inventors Protection Act, Public Law 106-113	Provides for the filing and publication of patent applications.
2003	21st Century Nanotechnology Research and Development Act, Public Law 108-153	Authorizes coordination of multi-agency expenditures in nanotechnology and requires societal consideration and public engagement in nanotechnology development.
2007	America COMPETES Act, Public Law 110-69	Expands R&D in agencies involved in physical sciences and expand opportunities for science technology engineering and mathematics

Expanded by the authors from Bozeman (2000), The following sections of this chapter highlight aspects of US innovation policies, beginning first with a review of selected framework (or indirect) policies that influence innovation. Consideration is then given to direct innovation policies, and policies to foster capabilities for innovation in the US. It should be noted that given the large size of the US innovation system and the diversity of direct and indirect innovation policies and activities, this chapter can only discuss a selected sub-set of policies. Additionally, although there are US innovation policies with a mission orientation (for example to promote medical, educational, energy, or military innovation), the chapter focuses primarily on innovation policies with a commercial orientation.

2.3.1 Framework and Indirect Policies

The legal and regulatory framework of the US is generally predisposed towards innovation, including encouraging innovators to take risk and to garner the rewards associated with innovation. The favorable regime for innovation in the US includes the flexibility to start, fail, and (hopefully) succeed at small business startups; the range of private capital pools available for innovation; adaptability of labor markets; and favorable tax terms are among the attributes of the US innovation system. At the same time, the US government's effort to improve the environment for innovation tends to focus narrowly on cost and regulatory issues. There is less activity (particularly at the federal level) in other areas, such as upgrading systems of vocational training for manufacturing (this is seen as a state and local responsibility). Recent framework policies related to innovation have thus been focused in three areas: intellectual property, tax policy, and procurement.

2.3.1.1 Intellectual Property

Intellectual property is administered through filings to the US Patent and Trademark Office (USPTO). In 2006, the USPTO received 440,000 patent filings and awarded more than 196,000 patents, nearly half of which were granted to foreign-owned firms. In that year, more than 354,000 trademark applications were filed with USTPO. Most US patents are owned by companies, with fewer than 2 percent of utility patents owned by universities. Three types of patents are stipulated by the USPTO: utility, design, and plants. Business method patents are treated similar to other areas in the patent examination process.

Prior to the current intellectual property regime, transfer of most federally-sponsored R&D was handled by the government. Contractors of R&D supported by federal funds such as universities or private non-profits did not have a consistent role. Influenced by the belief at the time that intellectual property available to all does not ultimately yield commercial value, the passage of the Bayh-Dole Act of 1980 (the University and Small Business Patent Procedure Act, Public Law 96-517) took place. Bayh-Dole made it possible for universities (along with small business and non-profits) to own the intellectual property rights associated with federally-funded R&D and license them to companies for use, allowing the federal government royalty-free license. Subsequent to this act, an increasing number of universities set up technology transfer offices to implement these precepts, ensure greater commercialization of their research, and generate new sources of revenue for the institution. That same year, the Stevenson-Wydler

Technology Innovation Act of 1980 (Public Law 96-480) was passed to permit federal laboratories to undertake technology transfer to industry. Agencies were required to create technology transfer offices to facilitate commercialization of inventions by industry. An amendment to the Act in 1986 formalized the technology transfer mission in the federal laboratories and instituted the Cooperative Research and Development Agreement (CRADA) to be used in joint R&D with private industry. Private companies were permitted to hold title to discoveries from these CRADAs. Subsequent actions led to the sharing of royalty income with the department (in the case of universities) or the laboratory division (in the case of government laboratories) and the individual inventor.

Patent reform has reappeared on the national agenda in recent years as part of concerns about the system's impact on innovation. The most significant since the 1950s was the American Inventors Protection Act (AIPA) passed in 1999 (amended in 2002). AIPA was designed to provide for publication of patent applications, enhance the efficiency of the patenting process, and increase intellectual property protection for inventors. In 2004, an influential study titled “A Patent System for the 21st Century” called for improvements to the US intellectual property system. (Merrill et al., 2004) Subsequently, patent reform acts were introduced into Congress, most recently The Patent Reform Act of 2007 introduced by the US House of Representatives (H.R. 1908). This act concerns prior user rights in the context of the US method of awarding patents based on "first to invent" relative to the "first to file" approach used internationally. It also contains changes in adjudicatory processes for intellectual property challenges. A similar measure has been introduced into the US Senate (S. 1145), though no new legislation has been formalized.

In the late 1960s universities received an average of 200 patents annually. By the mid 1980s this had increased to more than 500, rising rapidly to nearly 1800 patents in 1994 and more than 3000 patents in the 2000s. The Bayh-Dole Act has often been identified as a driver of this increase, although other studies have pointed toward factors such as the rise of biotechnology R&D (Mowery et al., 2001).

2.3.1.2 R&D tax credits

The federal Research and Experimentation (R&E) tax credit (known popularly as the R&D tax credit) is the main fiscal tool (outside of grants or loans) for stimulating R&D in the private sector. The federal R&E tax credit has been modified many times but the basic structure provides for four types of tax credits: the regular research credit, alternative incremental research credit, credit for basic research, and the energy research credit. The first three types of offerings provide for 20 percent reductions in qualified R&D expenditures above a base amount, whereas the energy research credit applies to 20 percent of payments made by businesses to nonprofit organizations for energy research. The federal R&E tax credit was originally established in 1981 in the Economic Recovery Tax Act of 1981 (Public Law 97-34) to temporarily stimulate R&E activity in the private sector. The major concern with the US federal R&E tax credit is that it is not permanent. The R&E tax credit expired in 2005 (for the twelfth time in its history as of 2007), although a temporary extension was passed. Calls for making the R&E tax credit permanent continue to be raised. The federal government estimated the cost of the R&E tax credit at $4.6 billion (€3.5 billion) in FY 2007. Most state governments also offer R&E tax credits, many of which are tied to national tax credit levels. Other tax credits (i.e. targeted tax incentives such as for the oil industry) tend to be rather broad so they may or may not relate to innovation. Studies of these R&D tax credits find that it can be difficult for small high tech startups to use; indeed NSF reported that fewer than 4 percent of R&D expenditures in the private sector were accounted for in the R&E tax credit claims. In addition, the lack of permanence, incentive effects, and complicated procedures have also been raised as concerns. Still, the impact of the R&E tax credit has been found to stimulate increased business R&D investment on a dollar-for-dollar basis and reduce the cost of R&D (National Science Board, 2006; Guenther, 2005).

2.3.1.3 Procurement

The US does not have a centrally-coordinated innovation procurement policy. The contracting out of government functions, including R&D functions, has been part of a trend toward privatization of public sector services. The idea behind this emphasizes the efficiencies of usage of the private sector, although it was originally borne out of the need for government to focus on World War II preparations. As a result, there was an increase in contracts for R&D and for management and operations (M&O) of the national laboratories, termed government owned contractor operated (GOCO). Indeed it was believed that these M&O contracts fostered improved technical, management, and research expertise. Most of the Department of Energy's government laboratories are GOCOs. However, the extent to which there is substantial competition in some government contracting areas, such as M&O contracts of the national laboratories, has not always been supported, in part because few private sector organizations are prepared to submit competitive bids (Bozeman et al., 2001).

The Office of Management and Budget operates the Office of Federal Procurement Policy, which helps direct federal policies associated with the $350 billion (€269 billion) expended by federal agencies annually on mission-related materials, supplies, and services.[3] Several related coordinating organizations - such as the Chief Acquisition Officers Council (CAOC), Federal Acquisition Institute and the Defense Acquisitions University - facilitate information sharing and training for public procurement workers. The Defense Department operates a dedicated Office for Acquisition, Technology and Logistics (and comparable offices in the service branches); the mission of this Office includes the assessment of defense-related technologies.[4]

The US has broad rules that advance development of contractor capability, including among firms owned by women and minorities. Typically, procurement awards are made based on explicit criteria such as cost, scientific merit, the organization's capabilities (i.e., equipment and facilities), and the background and experience of the principal investigator. The most common contracting entity is the defense contractor; organizations desiring to participate in the defense contracting process must follow a standard procedure to become a defense contractor which involves registrations and other re-

3 http://www.whitehouse.gov/omb/procurement/index.html

4 http://www.acq.osd.mil/

quirements. While registered contractors are at an advantage in many large government procurements, federal government policies for "strategic sourcing" permit agencies to consider criteria other than cost (such as performance, socio-economic goals, life-cycle costs, and vendor opportunities).[5]

To foster capability development for involvement in public procurement, the Department of Defense's Defense Logistics Agency operates the Procurement Technical Assistance Center program, which is comprised of nearly 100 offices in every US state. These centers assist firms in marketing their goods and services to the federal, state, and local governments through training and technical assistance provision.

2.3.2 Direct Innovation Policies

Despite the expressed philosophical limitations on federal innovation policy, there are many national programs that encourage innovation in industry through the direct provision of funding and technical assistance. Most of these programs focus on small business and many are hosted at universities. Prominent examples include the following:

2.3.2.1 SBIR/STTR

One of the major federal programs for providing funding for R&D in small businesses is the Small Business Innovation Research Program (SBIR). SBIR was created in 1982 through the Small Business Innovation Development Act of 1982 (Public Law 97-219). It requires federal agencies with substantial R&D budgets to provide special set asides for small business R&D. One of the underlying values of SBIR is raise US small businesses capabilities to meet federal R&D requirements. SBIR was reauthorized in 2000 and 2008. Eleven federal agencies with extramural R&D budgets of $100 million (€77 million) or more must reserve 2.5 percent of their R&D funding for SBIR applicants. Phase 1 SBIR awards offer up to $100,000 (€76,800) to conduct feasibility analyses. Phase 2 awards provide up to $750,000 (€575,700) to fund further proof of concept work. The SBIR model includes a Phase 3, which represents commercialization of the product or technology into the marketplace; however no federal funds are awarded in this phase. SBIR provided more than $2 billion (€1.5 billion) in awards, comprising 4,305 Phase 1 awards ($497 million or €382 billion in total funding) and 2,044 Phase 2 awards ($1,518 million or €1,165 million) in fiscal year 2004.[6] SBIR was further extended to partnerships between private firms and universities through the Small Business Technology Transfer Act of 1992 (PL 102-564), which established the Small Business Technology Transfer (STTR) program to fund cooperative research involving small businesses, universities, and federal laboratories.

The Innovation Development Institute – a non-governmental organization – has monitored SBIR and STTR awards. From 1983 through to 2006, the Institute reported:

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5 http://www.whitehouse.gov/omb/procurement/comp_src/implementing_strategic_sourcing.pdf

6 http://www.sba.gov/sbir (accessed February 8, 2007).

$20.6 billion (€15.8 billion) in total awards since 1983[7]; 70,056 Phase I awards (cumulative); 24,910 Phase II awards (cumulative); 16,222 participating firms; 57,280 patents granted; 1,496 venture capital investments, leveraging $26.8 billion (€20.6 billion) in venture capital; 597 publicly-traded companies; and 914 M&As (mergers and acquisitions).

These aggregated input and output measures are noteworthy. However, oversight and other independent evaluations of SBIR have raised issues both about performance and results. (Shapira, 2007) In 1999, the US Government Accountability Office raised concerns about the effectiveness of SBIR's commercialization goals and evaluation procedures.[8] In 2003, the Office of Management and Budget, using its Program Assessment Rating Tool (PART), found the Commerce Department's SBIR programme to be generally well-managed, but also raised issues about performance measures. In 2004, the National Academies of Science initiated a Congressionally-mandated study of the SBIR program which, in reports issued to date, has found the program to be useful but has suggested multiple improvement recommendations (National Academies, 2008).

Indeed, there has been an ongoing debate about whether SBIR substitutes, complements, or crowds out private finance, including private venture capital. Studies have suggested that there is a relationship between SBIR funding and receipt of private sector venture capital. Lerner (1999) found that Phase I SBIR awardees grew faster and were more likely to attract venture capital than similar non-awardees, although this effect was limited to those regions which already had venture capital and high-technology. A recent study by Toole and Czarnitzki (2005) finds that in the biomedical field there is increasing use of SBIR as a commercialization pathway, and that scientifically-linked SBIR awardees completing Phase II increased their chances of subsequent venture capital investment. It does seem that particularly in times in which private capital pools have been tight (such as after the dot.com downturn in the early 2000s) some firms have sought SBIR funding to replace private sources. Other research indicates that the SBIR program does contribute to innovation and commercialization. A recent study of the SBIR program of the Department of Defense finds that the SBIR did encourage R&D and commercialization that would not have otherwise taken place and that there were substantial societal gains from this commercialization (Audretsch et al, 2002).

SBIR is a nationwide program open to all eligible applicants irrespective of location. SBIR applications are subject to external review using consistent criteria within funding agencies. Nonetheless, a disproportionate share of SBIR funding tends to be concentrated geographically (especially in California) so there has been some concern about the geographic allocation of awards. Since there is regional clustering of high technology companies, an imbalance in awards is not surprising, since these locations will likely foster the growth of the most capable SBIR applicants. However, by US state (2006), the distribution of SBIR awards (Gini coefficient of 0.654) is less unequal than for ven-

7 Includes SBIR and a smaller university-focused program known as STTR (Small Business Technology Transfer Program)

8 GAO/RCED-99-114.

ture capital deals (Gini coefficient of 0.792). In 2006, the top five states garnered 67.3 percent of US venture capital deals; in the same year, the top five states for SBIR Phase I awards received 48.2 percent of all awards. So, while still concentrated, SBIR awards are more widely distributed geographically than private venture capital.[9]

On an annual basis, SBIR awards less than one-tenth of what is invested by the US venture capital sector ($25.5 billion in 2006),[10] however there is evidence that SBIR performs two important roles in the US innovation system. First, while scholarly debate continues, the weight of evidence indicates that SBIR is a complement to venture capital, for example by offering an early funding stream and certification mechanism for fledgling entrepreneurs to develop innovative technologies, which subsequently can then attract private funding. Second, SBIR may also serve as an alternate to venture capital, particularly in regions where venture capital is weak and in cases where entrepreneurs are developing innovations but do not have the high growth potential required by venture capital. SBIR also does not take or pre-empt equity, which can also be viewed as a positive design feature. Given the large size of the programme and its multi-agency operation, some variability in management performance is to be expected; however, oversight mechanisms (such as the GAO or PART) exist to identify and correct weak performance. The design element of requiring federal R&D procuring agencies to allocate a small percentage of their funds to start-up SMEs with promising technologies provides an important offset since most federal R&D procurement is allocated to larger enterprises and to institutional performers. Although run in a decentralized manner, SBIR offers a consistent pathway to innovative SMEs to access stages of early funding.

2.3.2.2 Advanced Technology Program / Technology Innovation Program

The Advanced Technology Program (ATP) was created in The Omnibus Trade and Competitiveness Act of 1988.[11] It was established to address national concerns that the lack of a government-industry joint R&D program was placing the US at a competitive disadvantage with Japan and other countries. (National Academies, 1999) Administered by NIST, ATP offers matching federal funds in technology commercialization awards to companies engaged in applied research in high risk technology areas. The program also has favored joint ventures in some of its solicitations. ATP works through formal solicitations for proposals, resulting in bottom-up submissions from industry which are selected through a peer review system. As of 2005, ATP made approximate-

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9 Analysis of FY 2006 SBIR Phase I Statistics by State (State Science and Technology Institute, http://www.ssti.org/Digest/Tables/120507t.htm) and 2006 US venture capital investment activity data (PriceWaterhouseCoopers MoneyTree Report, https://www.pwcmoneytree.com), reported in Wang and Shapira (2008) Partnering with Universities: A Good Choice for Nanotechnology Start-up Firms? Working Paper, Georgia Tech Program in Science, Technology and Innovation Policy, Georgia Institute of Technology, Atlanta.

10 PriceWaterhouseCoopers, MoneyTree Report, http://www.pwcmoneytree.com/moneytree.

11 1988 Omnibus Trade and Competitiveness Act. Title V (Technology Competitiveness Act), Subtitle B (P.L. 100-418)

ly 770 awards totaling $2.3 billion (€1.8 billion), which have been cost-shared by private industry since it began operations in 1990.[12] Most of the awards go to small high tech firms in fields such as electronics and photonics, information technology, advanced materials, and biotechnology. In addition, about one-half of the awards are received by small and mid-sized enterprises. ATP engaged in a very active evaluation program, funding some 45 evaluation studies, which are summarized in "A Toolkit for Evaluating Public R&D Investment." The main findings of these studies have been that ATP expanded and enhanced the R&D activities of the participating companies; high rates of collaboration were observed in ATP projects; and the outputs of ATP-funded projects were likely to lead to knowledge and market spillovers.[13]

Since its establishment, the ATP has been subject to considerable criticism, including from Republican members of Congress and the current administration, that it is an unnecessary intervention by government into aspects of the innovation process that are better handled by the private sector. In recent years, these concerns have results in periods of budget uncertainty for the program, despite support from the research and business communities and positive evaluation results. The America COMPETES Act (Public Law 110-69) signed on August 9, 2007 abolished ATP. In effect, this removes what had been a lightening rod of criticism for those who would wish the federal government to focus primarily on basic R&D and framework policies, rather than direct commercial innovation support measures. However, particularly since the COMPETES Act (discussed later in this chapter) also seeks to stimulate innovation, and indeed set up a programme – the Technology Innovation Program – that resembles ATP, the elimination of ATP does not signify the end of this ongoing debate about the desirability of direct federal government innovation policies bur rather its movement to new ground.

2.3.2.3 University-based Industry Consortia

The Industry-University Cooperative Research Centers (IUCRC) and the Engineering Research Centers (ERC) are two initiatives of the National Science Foundation (NSF) that link education, industry, and research missions. Both are based around a highly competitive peer review process and are focused on particular research areas of with commercial as well as academic and educational interest.

The IUCRC program began as part of a pilot program that ran from 1972 to 1979.[14] The program was fully authorized and expanded in the 1980s. The IUCRC program aims to foster research involving industry, universities, and government; support the development of research infrastructure; and provide research as well as educational opportunities to students.

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12 Advanced Technology Program, Highlights from ATP's Economic Studies, http://www.atp.nist.gov/factsheets/1-a-1.htm, Accessed October 10, 2007.

13 Source: ATP, A Toolkit for Evaluating Public R&D Investment. http://www.atp.nist.gov/eao/eao_pubs.htm, Accessed, October 11, 2007.

14 Source: NSF, National Science Foundation, Industry/University Cooperative Research Centers Program: 30 Years of Partnership, December 2003.

As of 2007, there are 55 IUCRCs which are hosted by single universities or networks of universities, with new center solicitations being proposed. Seven hundred firms are members of these consortia (including a small number of government agencies and nonprofit organizations). NSF provides seed money to help establish these centers, then supports administrative and other costs with annual payments of $50,000 (€38,400) for a period of five years. Centers can apply for a second five-year award, after which they are expected to be self-sustaining. Centers are required to obtain at least $300,000 (€230,300) annually in cash from fees from private sector members. A typical IUCRC's annual budget is in the range of $1-2 million (€0.8-€1.2 million)

The ERC program began in 1985 as a larger initiative to change the nature of engineering education while encouraging the creation university-based industrial consortia around high-risk research areas. ERCs sought to stimulate cross-disciplinary, team-based approaches, and industry orientations in engineering education. NSF supports each ERC for eleven years (conditional on intensive reviews every three years) at an average of $2 million annually. ERC budgets of roughly $10 million (€7.7 million) reflect a mix of NSF core support, other federal agency research grants and contracts, state and/or university money, and industry membership fees, contracts, and in-kind contributions. As of 2007, there are 20 ERCs.

Studies of these programs tend to find that they are valued by industry because of the access they provide to students and new ideas. However, industry participation has been found to be rather tenuous and limited. Universities are still learning how to interact with industry around issues such as intellectual property, and to provide tangible evidence of outcomes to sponsors when many of their highly valued products are intangible. (Feller and Roessner, 1995; Roessner et al., 1998; Feller et al., 2002) On the other hand, evaluations of the educational aspect of these centers has identified important impacts on the host universities in terms of interdisciplinarity, new course creation, greater involvement of undergraduates in research, and new organizational mechanisms to interact with industry. [15]

2.3.2.4 Business and Technical Assistance Services

The roots of technical assistance "extension" services in the US lie in The Smith-Lever Act of 1914, which created the Cooperative Extension Service (CES) in the U.S. Department of Agriculture. The Act provided federal grants to states to develop an extension system to transmit research results developed in state land-grant colleges to individual farmers through local extension agents. In rural areas, extension offices continue to be gateways for a range of business and technical assistance services.

In the 1950s, the federal U.S. Small Business Administration (SBA) was created to help small businesses through the provision of financial and business assistance services. Its programs offer small business loans, loan guarantees, venture capital, disaster-relief loans, information, management assistance, and advocacy. The SBA makes

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15 SRI International, Center for Science, Technology, and Economic Development, Research and Training Program Evaluation, http://www.sri.com/policy/csted/reports/university/ , Accessed October 10, 2007.

available equity capital to small enterprises with funds borrowed at favorable rates through some 418 private Small Business Investment Companies (SBICs) (as of fiscal year 2005). In addition, SBA directs several outreach services for small business through networks and partnerships that include more than 1,000 Small Business Development Centers, about 100 Women's Business Centers, and 19 Export Assistance Centers. Management assistance is also provided through the 10,500-strong volunteers of SCORE - the Service Corps of Retired Executives. [16]

The US Trade Adjustment Assistance (TAA) program was created in 1974 to help small and midsized manufacturers adversely impacted by import competition. With annual funding at around $10 million (€7.7 million), this program delivers services to manufacturers through a network of 12 centers. There are also programs with a mission to encourage innovation by transferring technology to a broad range of firms, including, but not limited to, manufacturers. These include the U.S. federal laboratories and the Department of Defense as well as other federal agencies sponsoring technology transfer services targeted at small and mid-sized firms.

In terms of an innovation and technology orientation, the Hollings Manufacturing Extension Partnership (MEP) program is one of the central services. The MEP's origins lie in the Omnibus Trade and Competitiveness Act of 1988, which supported the creation of three Manufacturing Technology Centers (originally with a planned life of 6-7 years). A further expansion of centers came in the early 1990s through U.S. Department of Defense funds under the federal Technology Reinvestment Program. Subsequent funding from the civilian budget of the U.S. Department of Commerce formed the MEP program, which is administered by the National Institute of Standards and Technology in the US Department of Commerce. Today, the MEP consists of a network of some 60 centers and more than 300 local offices in all 50 states. These are staffed by over 1,000 professional specialists typically with prior industrial experience. Originally, these centers were created to transfer state-of-the-art technology developed in federal laboratories. Experience suggested that few manufacturers had this need and that pragmatic services are the best path to innovation. Most centers deliver pragmatic assistance with business services, quality systems, manufacturing systems, information technology, human resources, and engineering and product development.

The strategies and organizational structures of centers depend in part on the history of assistance to manufacturers in the state or region. Some centers are organized as private non-profit entities; some as part of state agencies (such as the state Department of Commerce or Office of Science and Technology); and some are administered by universities or community or technical colleges. Similarly some centers provide most of the services with in-house specialists while others act as "brokers" who qualify external service providers and manage the relationships between these providers and their clients. The decentralized and flexible structure of the MEP allows individual centers to develop strategies and services appropriate to state and local conditions. The MEP program receives approximately $100 million (€76.8 million) of federal funding annually and requires centers to match every federal dollar with two state or industry dollars.

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16 US Small Business Administration, 2007, http://www.sba.gov, accessed October 10, 2007.

Evaluations of the MEP generally find it to be effective in terms of client impacts. (Jarmin, 1999; Shapira, 2003) In the mid 2000s, MEP sponsored a study conducted by the National Academy of Public Administration (NAPA) which found that the program was well run and effective. However, it judged the MEP to be too oriented toward cost savings and lacking in enough services and resources to foster innovation. (National Academy of Public Administration, 2004) The MEP recently created a new set of "MEP Innovation Services" to promote services that encourage new sales, new market development, new product development and advanced technology deployment. These services include the establishment of partnerships with existing innovation services such as SBIR and private sector experts.

2.3.3 Capabilities for Innovation

A further area for policy activities at the federal level involves the cross-cutting development of human and institutional capabilities for innovation. These activities occur nationwide and also in selected lagging states. While human capital is recognized as a fundamental resource in the national innovation system, the operation of primary, secondary and tertiary education is highly decentralized among the fifty states, thousands of local school boards, and educational institutions themselves. In the US, states and localities assume responsibilities for primary and secondary (K-12) education. Teaching in public colleges and universities is overseen and largely funded at the state level with significant institutional autonomy, while private universities are independently chartered. States and localities also run vocational and technical colleges. Nonetheless, the federal government is influential in the development of human capital, talent and skills through providing additional funding for K-12 education, stimulating curriculum reform and national testing, student loan programs, and sponsoring university research (almost two-thirds of all US university research is supported by the federal government). Since foreign-born scientists, engineers, and managers have long played major roles in the development of US R&D, innovation, and the development of entrepreneurial high-tech companies (National Science Board, 2008; Saxenian, 2002), federal policies towards such issues as immigration and foreign-born work and student visas are also significant. Additionally, the federal government takes an interest in developing capabilities for innovation in states and regions that are lagging. Examples of initiatives related to fostering innovation capabilities are presented below.

2.3.3.1 Human Resources.

The US has traditionally been open to international scientific talent. One fourth of US employees with college degrees in scientific and technological fields are foreign-born. However, post-9/11 security-related immigration policies and their effect on the procurement of visas have raised concerns about the ability of the US to maintain in-flows of foreign talent. Moreover, it has been observed that many American scientists who were influenced to get into math or science as a result of the "space race" and funded through The National Education Defense Act of 1958 are at or near retirement. Yet, science and technology careers are often judged to be less attractive than other options by domestic students.[17] These trends have raised concerns about the ability to support continued capabilities for innovation in the US.

At the early education level, one of the chief recent policy initiatives has been the No Child Left Behind Act (NCLB) of 2001 (Public Law 107-110). NCLB sought to enhance educational accountability through standards setting and assessment in reading, writing, and mathematics. Current perspectives on this program emphasize on the one hand successes from NCLB in measurement of reading and mathematics performance against academic standards. On the other hand, concerns have been raised about the adequacy of the funding, emphasis on standardized testing, lack of flexibility in educational governance at the state and local level, lack of standardization and comparability across states, and over emphasis on reading and math. Several evaluations of the NCLB have been conducted, suggesting the need for enhancing teacher and principal qualifications; providing comparable resources and better accountability to states and schools; reducing state-by-state variations in the stringency of tests; and attending to curriculum balance issues. [18]

Higher education policies have focused on the number and quality of science and engineering graduates in the US. America COMPETES Act. The act supports initiatives to provide improved tools for mathematics instruction to teachers, greater funding for mathematics and science related grant awards, greater funding for teacher training in mathematics and science, and increased access to advanced placement and international baccalaureate programs in math, science, and foreign languages. At the same time NSF issued the National Action Plan for 21st Century STEM Education, which was designed to further primary and secondary education in scientific technical engineering, and mathematics (STEM) fields. The plan emphasizes horizontal coordination among local, state, and federal governments and increasing the supply of primary and secondary teachers in these fields.[19] NSF has also funded six university-based Science of Learning Centers to conduct research and develop alternative tools to promote educational enhancement in informal as well as formal contexts.[20] Entrepreneurship education has been increasingly emphasized in recent years, particularly in business schools. The Kauffman Campuses Initiative, underwritten by the Kauffman Foundation, has awarded nearly $20 million (€15.4 million) to nine universities for entrepreneurship

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17 Conversely, it should be noted that one of the education and career options that has grown in attractiveness in the US is management, particularly through the growth of MBA (Masters of Business Administration) programs. For innovation (as opposed to scientific research and development), the proliferation of trained managers (including many with capabilities for entrepreneurship and innovation management) is a complementary asset.

18 Commission on No Child Left Behind, Beyond NCLB: Fulfilling the Promise of Our Nation's Children. http://www.aspeninstitute.org/site/c.huLWJeMRKpH/b.938015/k.40DA/Commission_on_No_Child_Left_Behind.htm, Accessed 21 August 2007; National Center for Education Statistics (2007); McMurrer, (2007).

19 NSF, 2007, National Action Plan for 21st Century STEM Education, Arlington Virginia: National Science Foundation.

20 Source: NSF: Science of Learning Centers, http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5567 (Accessed 21 August 2007)

curriculum development, research into entrepreneurship, facilities construction, technology tools, mentorship networking, and expansion of activities into liberal arts programs.[21]

2.3.3.2 Catch-up Regions

From time to time there are national level policies targeted to particular US regions that lag the nation in capabilities to foster innovation. For example, the 1930s saw the creation of the Tennessee Valley Authority to which promoted energy generation and economic development in relatively poor parts of the US Southeast. The Appalachian Regional Commission (ARC) was established in the 1960s to address economic development needs of the impoverished Appalachian region in the eastern United States. The ARC includes programs to serve small businesses through revolving loan funds, export trade promotion, e-commerce training, and entrepreneurship training and assistance. (US Government Accountability Office, 2007, p. 101) Two regional programs that are specifically targeted to raising localized innovation capabilities – EPSCoR and WIRED – are highlighted below.

The *Experimental Program to Stimulate Competitive Research* (EPSCoR) is a program to strengthen local scientific and technological resources of US states and territories that have historically received smaller amounts of federal R&D so that they can better compete in open research solicitations. EPSCoR requires US states and territories to create steering committees (including local universities, industry, governments), develop plans and analyses of strengths and weaknesses, and obtain state matching funds to prepare for submission of proposals to selected federal R&D funding agencies. The program was first created at the NSF in 1978 and has subsequently extended to six other federal agencies. As of fiscal year 2006, 25 US states, the US Virgin Islands, and the Commonwealth of Puerto Rico participate in the program primarily through their higher educational institutions. EPSCoR awards are based on competitive solicitations. The program budget is approximately $80 million (€61.4 million). An evaluation of the EPSCoR program in 1999 found that its states had changes their S&T environments, enhanced local university research, and increased their share of federal R&D funding. (COSMOS Corporation 1999)

The U.S. Department of Labor embarked on the *Workforce Investment Regional Economic Development (WIRED)* initiative in 2006. The objective of WIRED is to encourage collaborative approaches to innovation at the regional level through human capital activities and planning efforts involving workforce and economic development organizations. This initiative awarded $195 million (€150 million) to nearly 40 US regions through three solicitations in 2006 and 2007. The primary output of the program is the linking of research universities, venture capital firms, and economic and workforce development organizations and the creation of long-range strategic plans for skills upgrading and development in support of the current and long-range needs of local industry.

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21 Ewing Marion Kauffman Foundation, Kauffman Campuses Initiative, http://www.kauffman.org/items.cfm?itemID=475 (Accessed 21 August 2007)

2.3.4 Coordination and System Stimulation

One of the strengths of the innovation system in the US – its highly fragmented and decentralized nature – can also be a source of challenge particularly at the level of the federal government. Public research funding at the national level typically is implemented through federal agencies rather than through a single centralized source. Assistance services are typically implemented at the state and local levels. And capability raising programs rely on the ability of state and local participants to develop new partnerships and networks. Recent studies have raised the need for improved system-wide governance of the innovation system to ensure more effective innovation policies and efficient use of resources. (Council on Competitiveness, 2004) Two initiatives designed to address the need for enhanced coordination – National Nanotechnology Initiative and the America COMPETES Act – are in the following sections.

2.3.4.1 National Nanotechnology Initiative

The National Nanotechnology Initiative (NNI) is an umbrella organization that has been used to develop and coordinate federal policies, R&D activities, and technology transfer in the emerging area of nanotechnology. In 2001, the NNI was set up to coordinate federal agencies' R&D activities to advance the development of nanotechnology. The number of agencies participating in the NNI has expanded from six in 2001 to 24 by 2006, of which 11 agencies are involved in R&D budgeting coordination and 13 others are engaged as in-kind partners. The federal R&D budget for nanotechnology is over $1.44 billion (€1.11 billion) in FY 2008, with a total federal nanotechnology investment of $8.3 billion (€6.4 billion) since 2001. (National Nanotechnology Initiative, 2007) The NNI operates under the Committee on Technology of the National Science and Technology Council (NSTC). The NTSC is located in the Office of Science and Technology Policy in the Executive Office of the President. The NSTC's Nanoscale Science, Engineering, and Technology (NSET) Subcommittee coordinates the plans, budgets, programs and reviews for NNI. The National Nanotechnology Coordination Office (NNCO) provides technical and administrative support to the NSET Subcommittee. The NNI engages in cross-agency communication and dissemination and participates in the setting of budgetary priorities, along with the federal agencies which provide funding for nanotechnology-related activities to individual investigators and to research centers. In May 2005, the Presidents Council of Advisors on Science and Technology (PCAST) reviewed the activities of the NNI. In its report, "The National Nanotechnology Initiative at Five Years," the review concluded that that the NNI was well-managed, but needed to be more involved in coordination with the states and needed to remain flexible to respond to increased global competition. (President's Council of Advisors on Science and Technology, 2005)

2.3.4.2 America COMPETES Act

One of the major innovation initiatives of the US administration is The America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education and Science (COMPETES) Act. This act, signed into law in August 2007, is a broad interagency initiative to expand R&D investment and increase support for science and technology education. It was a response to recommendations from recent policy reports by the Council on Competitiveness, the National Academies, and the Office of Science and Technology Policy regarding the enhancement of innovation policy. (Council on Competitiveness, 2004; National Academies, 2006; Office of Science and Technology Policy, 2006) The goal of the act is to strengthen framework conditions for business innovation. The act has three main elements: (1) strengthening research investments, (2) opening educational opportunities in science and technology areas, (3) support greater infrastructure for innovation management. The first element involves doubling of the R&D budgets of three agencies: NSF, the laboratories at NIST, and the US Department of Energy's Office of Science. In addition, all agencies are to allocate more of their R&D budgets toward blue sky research. The second element provides increased support for educational opportunities, scholarships, and teacher training in the science, technology, engineering, and mathematics fields from early educational levels through graduate school. It also restructures the management of innovation programs within the Department of Commerce, eliminating the Technology Administration, creates a President's Council on Innovation and Competitiveness, and charges NIST with the implementation of a new Technology Innovation Program.

2.3.5 State Innovation Policies

Although as noted in the prior section, there are a few federal policies that have a targeted geographical orientation, in the US federal system the lead responsibility for regional innovation policy remains with the states. This is consistent with long-established state leadership roles in economic development and education in the US. Within states, cities and other localities also are able to develop their own innovation policies.

US state and local innovation policies are shaped in a dynamic "bottoms-up" approach which allows for flexibility in addressing changing areas of emphasis and organizational functions. In the 1990s and early 2000s, information and communication technology attracted a large measure of state and local level plans and initiatives. The 1990s saw the rise of life science programs at the regional level, which in part corresponded to the doubling of the R&D budget of the National Institutes of Health (NIH) at the national level. By the mid 2000s, nanotechnology and energy and clean technology areas were encouraged. The roles of organizations involved in regional level innovation policies have also changed, with universities taking on a more fundamental role in regional innovation beyond conventional teaching and research missions. As a result, more and more universities have put into place incubators, licensing offices, technical outreach to businesses, spin-off of start-up companies, and seed capital funds.

One recent example of state innovation policy which has attracted much attention is the California Research and Innovation Initiative. The $95 million (€73 million) initiative, financed through revenue bonds, includes several clean technology efforts such as the Helios Project to build an alternative energy research facility at the Lawrence Livermore

Laboratory at Berkeley California and a new Energy Biosciences Institute supporting research into cleaner fossil fuel production and biomass research.[22]

2.3.5 The Credit Crunch and System Stimulation: Innovating Out of Crisis?

There have been periods of crisis throughout US history when the federal government provides a strong and active response that has implications for innovation. For example, government intervention during the Great Depression of the 1930s included major public works programs that laid a framework for renewed economic development, while the 1960s saw a dramatic increase of space-related activity followed the launch of Sputnik. A heightened level of federal government activity, following the election of Barack Obama to the presidency and Democratic Party majorities in both the US House and Senate, is seen again in the US response to the global financial crisis and economic downturn which emerged in late 2008. This rapid response to system crisis is represented in the passage in February 2009 of the large-scale short-term stimulus package, the American Recovery and Reinvestment Act or ARRA (Public Law 111-5). ARRA authorizes $787 billion (€604 billion) in stimulus expenditures, which 40% are in appropriations and the rest come from a combination of tax relief and “mandatory entitlements” (including healthcare and retirement allocations). ARRA includes appropriations for infrastructure, human services, energy and environment, and scientific research. Indeed, the Obama administration seeks to use stimulus spending not only to provide short-term relief to create jobs and business opportunities but also to link to longer-term innovation objectives. About 13 percent, or $101.9 billion (€78.2 billion), of the stimulus package is devoted to technology, energy and R&D spending. This includes $45.1 billion (€35.0 billion) in renewable-energy incentives, $19.6 billion (€15.0 billion) for health-care information technology, $11.0 billion (€8.4 billion) to develop smart electricity grids, $7.2 billion (€5.5 billion) to expand broadband internet access, and $19 billion (€15.0 billion) for increased public R&D investment. Within the increased R&D allocations, $11.1 billion (€8.5 billion) will go to the National Institutes of Health and $3.0 billion (€2.3 billion) to the National Science Foundation (Rottman, 2009). These stimulus funds are huge when compared with the FY 2008 budgets for these agencies (up 38 percent for NIH and 49 percent for NSF). Fears that this would be a “one-time” commitment by the administration to technology and innovation have been allayed by an increase in the base budgets for federal R&D agencies of 4.7 percent above the 2008 levels in the FY 2009 budget and by President Obama’s reference to a new national goal for US research and development expenditures to exceed 3 percent of gross domestic product.[23] Debate in the US now seems to be shifting from whether there is enough federal budget for R&D and technology to whether the uses of these funds will achieve desired technological, economic and societal objectives (Rottman, 2009).

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22 For additional examples of state and local innovation policies in the US, see the State Science and Technology Institute (http://www.ssti.org).

23 Remarks by President Barack Obama at the National Academy of Sciences Annual Meeting, Washington DC, April 27, 2009.

2.4 Assessment and Evaluation

The assessment and evaluation of innovation policy (and other policies) in the US relies on a networked approach involving diverse agencies and methods. (Shapira, 2001) This is underpinned by processes of federal system decision-making founded on checks and balances in which the executive, legislative, and judicial branches of government have authority to veto, review, and deliberate on actions of the other branches.

However, the innovation system has further evaluative mechanisms which include competitive proposals and external expert review. The private sector also participates in assessments through appointments to high level policy making councils such as the President's Council of Advisors on Science and Technology (PCAST) and membership in private non-profit organizations such as the Council on Competitiveness.

The budgetary process managed by the Office of Management and Budget incorporates the most regularized assessment of policy. In the 1990s, the Government Performance and Results Act added quantitative elements to this assessment, one of which is the Program Assessment Rating Tool (PART). OMB specialists use PART to identify strengths and weaknesses of a program, drawing on quantitative and qualitative information furnished by the programmatic agency. The results of these assessments typically influence the funding amounts which wind up in the President's budget. Congress also conducts assessments through its traditional oversight function which employs committee hearings and expert testimony, and also issues requests to the Government Accountability Office (GAO) to conduct formal program audits. Executive branch agencies themselves will sponsor external evaluations of their programs, which eventually feed into learning and evidence for the budgetary process.

There are a few specific assessment mechanisms that apply specifically to the innovation policy area. The private non-profit National Academies is often called on by Congress to conduct assessments on policies of a scientific and technical nature. In addition, the NSF publishes Science and Engineering Indicators, which are used to track innovation in the US relative to other countries, particularly in areas such as tertiary education graduates and patents. (National Science Board, 2008) NSF also partners with other agencies on survey of industrial R&D (National Science Foundation, 2006) and on an analysis of the effect of R&D investment on US economic growth. (Bureau of Economic Analysis 2007)

Despite these multiple approaches, no system-wide assessment of US innovation policy measures has taken place outside of the budgetary process. While several important policy evaluations have been conducted, some have resulted in changes to innovation policies and programs while other programs have been challenged to respond as a result of general inertia or other factors. Moreover, high quality evaluations and positive findings do not ensure that innovation programs will continue. For example, despite the ATP's investment in 45 high quality studies of its impacts and further positive findings by the National Academies, the program was discontinued in the America COMPETES Act.

There is recent interest in the US in improving innovation measurement and assessment. The US Department of Commerce appointed an advisory committee of business leaders and academic researchers entitled, "Measuring Innovation in the 21st Century Economy" to explore improved innovation metrics. The Director of the Office of Science and Technology Policy in the Executive Office of the President has called for new research on the measurement of linkages between R&D, innovation, and economic and societal outcomes. This has led to a new NSF-supported initiative known as the Science of Science and Innovation Policy. (Lightfoot, 2006) One continuing challenge in these initiatives is they tend to stress scientific and high-technologically measures (such as publications, patents, and licensing), which can have the effect of overemphasizing the US position in innovation by playing to US strengths and underplaying other aspects of innovation.

In addition to this formal side of assessment, there are efforts in government agencies and private non-profit organizations to promote comparison with and learning about approaches and practices that advance innovation. There are a set of organizations that are involved in producing rankings of US cities and/or states based on innovation indicators. The Information Technology and Innovation Foundation publishes a New Economy Index that benchmarks states and metropolitan areas against one another based on aspects such as knowledge workers, globalization, economic dynamism, digital economy, and innovation capacity.[24] The Milken Institute publishes indexes that compare US states in areas such as science and technology and knowledge-based economy attributes; compare countries based on capital access; and compare cities based on economic dynamism.[25] The National Science Foundation publishes Science and Engineering Indicators, which compares states on various S&T attributes and benchmarks the US with other countries (National Science Board, 2006).

2.5 Conclusions

The US has diverse approach to innovation policy making and program development. Many layers and levels of activities are involved which, taken together, result in an overall innovation policy. While the end results to date have generally been positive (the US remains a world leader in most areas of innovation activity), this model does highlight concerns about coordination issues within the federal government and between the federal government, state and local governments, and private sector policy, finance, and business communities.

The US system encourages learning in innovation policy, as different agencies or states experiment with policies or approaches, which can then be taken up elsewhere or expanded if they prove to be successful. The US is often quick to establish innovative national approaches, as for example with the National Nanotechnology Initiative, SBIR, or the MEP, which are often used as models for national policymaking in other countries. When motivated, the federal government can also marshal and apply significant resources (as with NNI) or promulgate major legislative changes (as with the

24 The 2007 State New Economy Index, http://www.itif.org/index.php?id=30 accessed July 12, 2007

25 http://www.milkeninstitute.org/research/research.taf?cat=indexes, accessed July 12, 2007

Bayh-Dole Act) that can influence technological development and innovation. At the same time, it is also possible for outdated or inefficient policies and programs to be maintained: although the federal executive, particularly through the Office of Management and Budget, does review and flag programs for funding reduction or cancellation, Congress has to concur (and often this does not occur). Similarly, Congress – through hearings or GAO studies – can flag problems in federal administration of innovation-related policies, but practices in federal agencies are often hard to change.

The US innovation system does have strength and retains substantial and powerful capabilities to foster innovation. Yet, in recent years, there has been increased debate and concern about weaknesses in the innovation system and innovation policy. Growing global competition, particularly from China and India, has fuelled this debate.[26] One outcome is the 2007 America COMPETES Act, which does increase funding for several federal R&D agencies and boost efforts to improve math and science education. However, this is not a fully comprehensive approach, and debate continues about the need for additional legislation and policy development, ranging from patent reform to exploiting the innovation opportunities presented by climate change and alternative renewable energy resources. Numerous studies, commissions and organizations have highlighted US innovation performance and policy gaps.

A further strength of the US system is its capability to absorb change and take active and stimulative action at points of crisis. The new federal administration's stimulus legislation passed in February 2009 reflects a rapid response capability of the system to quickly increase federal spending that is hoped will result in long-term renewal and innovation. Moreover, early budgetary priorities emphasize new directions for innovation including the development of policies and programs for clean-tech research and innovation and by commitments to expand US research and innovation capabilities to move away from foreign oil dependence. The establishment of the NNI (coupled with increased funding for nanotechnology-related sciences) hints that the mechanism of federal interagency coordination might be further encouraged in other innovation policy arenas. Finally, increased interest in (and hence monitoring of) monitoring of global innovation developments, particularly in China and India, as well as results from some of the projects sponsored under the Science of Science and Innovation Policy initiative should provide an enhanced information and assessment base for future US innovation policy development.

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26 In the post-World-War II era, external global competitors that have prompted rounds of new US federal innovation activities have included the Soviet Union (in the 1950s and 1960s) and Japan (in the 1980s).

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