ERAWATCH COUNTRY REPORTS 2012: United States of America

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Executive Summary

The United States of America (US) has the largest economy in the world with GDP (purchasing power parity) of around €12.2 trillion ($15.2 trillion) or €38,800 on a per capita basis, ($48,111).[1] Its population is the third largest in the world and the largest among countries in North America, comprising nearly 68% of all North Americans.

The US has diverse and established scientific agreements with the EU. Formal science and technology cooperative agreements have been instituted between the US and Europe at the European and individual country level and there also are networks that promote US-European scientific cooperation, science and technology presence within diplomatic offices, academic exchange programmes, and cooperative actions of individual organisations and researchers.

The US has a large R&D sector – representing more than €320b ($406.7b) in 2011. GERD (in US dollars) rose by 1.8% from 2010 to 2011, after having dropped by 0.5% from 2008-2009, and recovered slightly (0.7%) from 2009-2010. This positive growth rate for R&D is less than that of the larger economy (i.e., GDP), which grew by 3.9% during the same time period. The private sector funds more than 60% of all R&D and performs nearly 70% all R&D. Government funding accounts for more than 30% of R&D in the US, but government-funded public research organizations perform less than 12% of all R&D, with higher educational institutions performing the lion's share of the remainder (Youtie 2012). The slower growth of R&D expenditures reflects diminished private sector investment of -0.1% from 2010-2011 as a result of the ongoing economic and economic and financial crisis. Ongoing concern about rising budget deficits has resulted in reductions or modest increases in government-funded R&D in subsequent years, although not for this reporting period, which still reflects government expenditures from the American Recovery and Reinvestment Act (ARRA) of 2009.

At the national level, the US system has long had a direct policy emphasis on research investments but few explicit initiatives for promoting private investments in R&D. The current administration has initiated several cross-agency programmes over the past three years to foster greater linkage between research and innovation policy including initiatives in 2011-2013 supporting advanced manufacturing. Nevertheless, continued uncertainties prompted by the economic downturn and sluggish recovery have been a major barrier to private R&D investments in the US. Addressing the economic downturn and budget deficits remains an ongoing concern of US policy. As a result, compromises on the federal budget have been difficult to reach and budget extensions have been frequent. The fiscal 2013 budget has been subject to sequestration (automatic mandatory budgetary spending cuts by a specified percentage) and is under continuing resolution at prior fiscal year levels. The fiscal year 2013 budget after final appropriations and sequestration reflects 6.5% in R&D-related budget cuts. As a result of these reductions, there is limited flexibility to make substantial new federal investments R&D, and limited scope to consider comprehensive legislation to address gaps in linkages between research and private sector R&D. These limitations have engendered concern among policymakers who

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[1] 1 euro=1.25 US dollars.

note needs for investment in research, education, manufacturing, entrepreneurship, and infrastructure (US Department of Commerce and National Economic Council 2012).

Knowledge Triangle

US support for research policy reflects the generally favourable view of the role of the federal government in making science investments. Investment in research that addresses grand challenges is exemplified by health, clean energy, national security, and education. Innovation policy has seen fresh activity in the manufacturing sector, along with continued support for regional innovation clusters and continuing implementation and monitoring of patenting reforms. Education quality is an ongoing concern in the US, although it is primarily the purview of state governments, with the federal government having a limited role with an orientation toward science, technology, engineering, and mathematics (STEM) education. Other policy areas such as climate change are raised from time-to-time, but they are less important compared to economic recovery and federal budget deficit reduction.

	Recent policy changes	**Assessment of strengths and weaknesses**
Research policy	There has been continued pressure to reduce non-discretionary spending but the President's 2014 proposed budget if approved would represent an 8% increase in Federal R&D spending.	Future budgets are likely to undergo reductions that will affect overall amount available for R&D. In addition, legislation has been introduced to eliminate funding for some research programmes in the social sciences at the National Science Foundation.
Innovation policy	Advanced manufacturing is a priority, three advanced manufacturing institutes as part of the National Network for Manufacturing Innovation planned for 2013, Manufacturing Technology Acceleration Centres, and a community-level programme investing in partnerships between manufacturing, government, and universities.	The US generally has a favourable environment for innovation, particularly the innovativeness of US companies, quality of universities and flexibility of the labour market (World Economic Forum 2012). However, low ranking in levels of distrust of policy makers, burdens on the private sector, and budgetary and macro-economic instability limit US competitiveness.
Education policy	New programmes promote STEM teacher training and certification to produce 100,000 teachers in 10 years, including the National Math and Science Initiative (NMSI) in partnership with the Howard Hughes Medical Institute (OSTP 2013).	Tertiary education continues to be an asset of the US system. Primary and secondary education in the US frequently compares less favourably with international counterparts. State budget shortfalls persist, with less money going to primary and secondary education and steep tuition increases by public universities and colleges prompting public outcry.
Other policies	The National Oceanic and Atmospheric Administration (NOAA) released a five-year R&D plan which places greater priority on climate change and sustainability.[2]	Although the US has strong programmes in the energy and environmental areas, for example the Advanced Research Projects Agency-Energy (ARPA-E), the US has not passed any major energy and environmental legislation over the past year, in part because of concerns about the effects of these types of regulations on the economic recovery.

[2] http://www.noaa.gov

Assessment of the national policies/measures

The US has long been a desirable location for international education and research work in part because of the quality of its universities. In addition, the US has a solid research infrastructure with access increased in recent years through investments small scale research infrastructure. Concerns about the level of funding for university research have been raised in light of state and federal budget cuts. Although large scale technology transfer policies are not widespread in the US system, the innovativeness of the private sector and success of measures such as the SBIR programme are indicative of a system in which the private sector and research institutions have collaborative engagement. Budget constraints result in the US investing less over the past year in international exchanges of researchers. The longstanding Fulbright Hayes programme, which received budget increases after the 9/11 terrorist attacks, was cut substantially in fiscal year 2012 to €184m, $230m from €190m, $238m in 2011; the program received a slight 0.6% increase in the 2013 continuing resolution budget. Although these budget signal elimination of dissertation and research abroad awards, the US still maintains numerous linkages with EU and non-EU countries through multiple mechanisms including 54 umbrella science and technology agreements.

	Objectives	**Main national policy changes over the last year**	**Assessment of strengths and weaknesses**
1	Labour market for researchers	The fiscal year 2013 budget for the Fulbright Hayes programme was 0.6% higher than the previous fiscal year.	The US has long been a desired location for international education and work. However, national security issues and concerns about the availability of jobs for the domestic labour force have at times limited the openness of the US market.
2	Research infrastructures	Infrastructure for assessing large scale data has received renewed attention through a series of multi-agency solicitations termed “Big Data”, which seek to receive more knowledge from large scale datasets.	Small scale research infrastructure at universities and other research institutions has received support but large scale infrastructure remains an issue (National Academies 2006).
3	Strengthening research institutions	The President’s Council of Advisors on Science and Technology issued a report, “Transformation and Opportunity: The Future of the U.S. Research Enterprise” in November 2012, which highlights challenges faced by university, government, and private sector institutions and calls for several specific recommendations including setting R&D expenditures at 3% of GDP, eliminating superfluous regulations for research-intensive businesses and universities, and developing federal budgets for future year funding of R&D (PCAST 2012).	The US higher education system is large and diverse. It research universities are often at the top of global rankings. (Times 2012). Declines in the US world share of articles continue to be monitored (National Science Board 2012) and concerns about funding streams available for university research (National Research Council 2012).
4	Knowledge transfer	The Small Business Innovation Research (SBIR) programme has new amendments to its regulations concerning ownership, control and	The US has a strong and innovative private sector with great capacity to absorb and develop innovations. However,

		affiliation, which went into effect in January 28, 2013. The new amendments allow small firms that are majority owned by multiple venture capital companies to participate in the programme.	outside of SBIR, there are few programmes with substantial scale to promote widespread public-private cooperation and knowledge transfer. Private sector firms are concerned about the administrative costs associated with these kinds of relationships.
5	International R&D cooperation with EU member states	Networks of Diasporas in Engineering and Science (NODES) were established in 2012 to build greater connections with foreign scientists in the US.[3]	The US has 15 umbrella science and technology agreements with EU member states and one with the EU. There is no national strategy for these types of R&D cooperation.
6	International R&D cooperation with non-EU countries	(Refer to number 5 above)	The US has 38 umbrella science and technology agreements with non-EU countries. There is no national strategy for these types of R&D cooperation.

[3] http://www.state.gov/r/pa/prs/ps/2012/07/195525.htm

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1 INTRODUCTION

The main objective of the ERAWATCH International Analytical Country Reports 2012 is to characterise and assess the evolution of the national policy mixes of the 21 countries with which the EU has a Science and Technology Agreement. The reports focus on initiatives comparable to the ERA blocks (labour market for researchers; research infrastructures; strengthening research institutions; knowledge transfer; international cooperation). They include an analysis of national R&D investment targets, the efficiency and effectiveness of national policies and investments in R&D, the articulation between research, education and innovation as well as implementation and governance issues. Particular emphasis is given to international research cooperation in each country.

2 PERFORMANCE OF THE NATIONAL RESEARCH AND INNOVATION SYSTEM AND ASSESSMENT OF RECENT POLICY CHANGES

2.1 MAIN POLICY OBJECTIVES / PRIORITIES, SOCIAL AND GLOBAL CHALLENGES

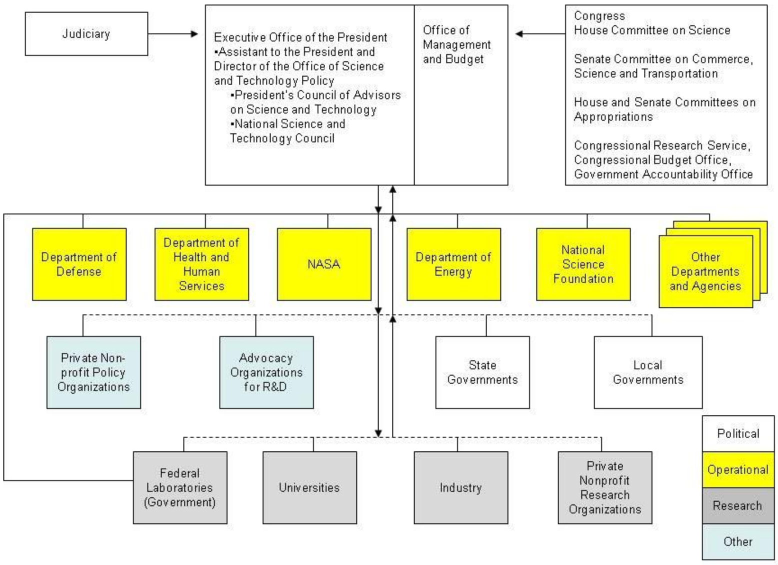
Grand challenges play a pronounced role in US research and innovation strategy. Although it is recognized that "future challenges are impossible to predict" (Executive Office of the President, 2009), research and economic strategies for the US are increasingly relating policy initiatives to grand challenges. The 2011 updated Strategy for American Innovation includes a list of national priorities for which innovative breakthroughs can spur advances: clean energy, biotechnology, nanotechnology, advanced manufacturing, space capabilities and applications, health information technology systems, and educational technologies (Executive Office of the President, 2011).

2.2 STRUCTURE OF THE NATIONAL RESEARCH AND INNOVATION SYSTEM AND ITS GOVERNANCE

Main actors and institutions in research governance

The US research system is large and decentralised. Policy is shaped in a bottom-up manner through the activities of departments and agencies with substantial intramural and extramural R&D. The leading departments and agencies based on size of public R&D expenditures are the US Department of Defence and the Department of Health and Human Services. In terms of basic research, the National Science Foundation (NSF) is a key player. Although the research system is decentralised and fragmented, budgetary policy plays a role in priority setting through an annual budgetary process. The budgetary process is managed by the *Office of Management and Budget*; although the US has no formal R&D budget, agency R&D budgets are coordinated through the Office of Science and Technology Policy (OSTP). This agency, which is within the Executive Office of the President, engages in several types of coordination activities, including review of research budgets, coordination of budgets in crosscutting areas, and provision of advice to the President on areas of importance in research policy.

Figure 1: Overview of the US research system governance structure



Source: Youtie (2013).

The institutional role of regions in research governance

The US is a federal system, with governmental powers not explicitly allocated to the national government reserved to the state and local governments. State governments also delegate powers to local governments. As a result, the US has a multi-level system of regional governance which includes 50 states; five equivalent legal territories; more than 900 metropolitan and micropolitan areas, more than 3000 counties, boroughs, and parishes; and more than 25000 cities and towns. Each state has a different governance structure for local entities. Some powers are shared between national, state and local governments, such as the power to tax.

State governments play the principal role in regional research policy. State research policy governance is most significant in the following areas: R&D tax credits, governance of public university activities including hiring of researchers at universities and other state-funded public research organisations, and bond issuance to provide funding for research facilities. States also are prominent in economic development promotion, including technology-based economic development.

The state governor and legislature are the primary policy actors in all 50 states. In addition, state research policy may involve science and technology programme administrators, state administrators of federal research programmes, university administrators, and private non-profit organisations such as industry and professional associations. Some states have more centralised structures involving science councils and administrators, whereas other states distribute these functions across multiple organisations. Elected officials, along with science and technology programme administrators, on policy design and planning. Science and technology programme administrators usually have primary responsibility for implementation, along with state administrators of federal research programmes, and university administrators. Industry and professional associations often serve in an advocacy capacity.

The distribution of research funding in the US is concentrated mostly along the eastern and western coast. California is the largest location of research activity, performing nearly 22% of US R&D. The next largest states are New Jersey, Texas, and Massachusetts. Once the size of the state is accounted for – by dividing R&D by GDP for example – Washington has the highest business R&D expenditure as a percentage of GDP and Maryland (part of the US capital metropolitan area) has the highest government R&D expenditure. States in the south and west tend to be positioned much lower in normalised rankings because they have experienced population growth without concomitant R&D growth. Business expenditures on R&D are most prevalent in Michigan, which is where many R&D intensive automobile firms are headquartered.

Main research performer groups

The private sector performs nearly 70% of all R&D. Government funding accounts for more than 30% of R&D in the US, but the government (via public research organisations) performs less than 12% of all R&D, either internally or through Federally Funded R&D Centres (FFRDCs). Higher educational institutions perform 15% of the R&D. Private sector R&D funding is slightly down in 2011, reflecting the economic downturn. Government funding is higher in 2011 in part because of multi-year grants related to the one time economic stimulus expenditures, which included €14.6 billion ($18.3 billion) of R&D spending through the ARRA.

2.3 RESOURCE MOBILISATION

2.3.1 Financial resource provision for research activities (national and regional mechanisms)

The US does not have a formal R&D investment target. However, the current administration has placed greater emphasis on increasing R&D as a percentage of GDP beyond the 3% mark; this level of investment was referenced in the president's 2009 growth strategy and re-affirmed in the 2011 update (Executive Office of the President 2009, 2011). Gross R&D expenditures did not keep up with economic expansion, however. R&D as a percentage of GDP dropped from 2.9% in 2009 to 2.8% in 2010 and 2.74% in 2011 (Boroush 2013). There is no formal prioritisation of public investments in R&D to ensure this increase. Nonetheless, legislation such as the America COMPETES Act has called for a doubling of the R&D budgets of three basic federal science agencies. The original objected was to provide for a seven-year path for this doubling. However, the economic downturn and rising budget deficits resulted in a lengthened path in the 2010 and subsequent year budgets (Sargent

2010). Budget sequestration resulted in a 6.5% decline in government R&D spending in the fiscal year 2013 budget.

The US does not have long-range budgeting. The US budget is based on a fragmented and decentralised process. All agency budget proposals are sent to the Office of Management and Budget (OMB), which uses an assessment process that incorporates the Programme Assessment Rating Tool (PART). This tool highlights strengths and weaknesses of federal programmes, drawing on quantitative and qualitative information provided by the administering agencies. The results of these assessments are often reflected in the President's budget. Congress then holds hearings on the budget and either a budget is agreed or, increasingly more common, the previous fiscal year budget is extended in a continuing resolution. This process does not incorporate long range, multi-year budgets, including for R&D. At the same time, the US Office of Science and Technology Policy (OSTP) coordinates the R&D budget across all agencies as part of the budgeting process.

The main funding instruments are represented by the federal departments and agencies with the largest R&D budgets. These are the Department of Defence, Department of Health and Human Services, National Aeronautics and Space Administration (NASA), Department of Energy and NSF. Each agency focuses on a distinctive mission, including in its R&D programmes: i.e., defence, health, aerospace, energy, and basic science. The US does not have formal regional support schemes or R&D objectives for the states. There are certain programmes that apply to states that rank in the second half of the states in terms of R&D expenditures, for example, the EPSCoR programme. However, these programmes are small in size – €360m ($450m) compared to the overall R&D budget (roughly €110b). These programmes are mostly competitive rather than institutional. Many of these competitive programmes require a local match from the applicant. In addition, the states themselves offer R&D tax credits, many of which are tied to credits reported through the federal Research and Experimentation Tax Credit. Few companies take advantage of this tax credit, with only 4 percent of R&D expenditures in the private sector accounted for in the R&E tax credit claims. (National Science Board 2006) There is no national mechanism to promote collaborative funding, but it does occur in selected programmes such as the Small Business Technology Transfer Programme, which promotes R&D in company-university partnerships. This programme amounts to 0.3-0.5% of the budgets of agencies with €0.8b ($1b) or more in extramural research. There have been some debates about the ability of competition-based, peer-reviewed project funding to engender creative research in the US. Some observers suggest that longer-term and more stable funding is associated with more creative research, while project-based and competitive proposals are accompanied by significant administrative costs. (Azoulay et al, 2009)

Recent policy changes affecting the funding of research are focused on budget reductions for upcoming budgets. The Office of Management and Budget issued guidelines requiring 5% budget cuts over fiscal year 2013 appropriations levels for the fiscal year 2014 budget, and these guidelines were furthered by automatic cuts from sequestration. The growing importance of grand challenges is reflected in these guidelines which, although they do not set specific shares of the budget to be allocated to grand challenge areas, require prioritization given to grand challenges in advanced manufacturing; clean energy; climate change; R&D for informed management and ecosystem sustainability; IT; nanotechnology; the biological sciences; STEM education; and innovation and commercialization (Office of Management and Budget 2012).

The US does not have a long-term, cross agency strategy to build mutual trust between science and society. However, certain agencies have particular programmes to support societal issues. For example, the National Nanotechnology Initiative allocated 2% of its budget to addressing education and societal dimensions in 2012.

2.4 Providing qualified human resources

The US does not have a formal national research system. Human resource development for research is split at the graduate level between NSF and National Institutes of Health (both of which provide fellowship funding in research grants) and state level higher educational systems. The federal government also offers loans and grants for vocational and higher education and some state governments offer scholarship programmes for qualified students. This fragmented system makes for greater opportunities for entry but less coordination.

Human resources in science and technology (HRST) are estimated at 5.6% of the share of total labour force, which is below the EU27 average (40%) although the figures are likely not fully comparable (Youtie 2013). Concerns about the availability of human resources in science and technology have been expressed from time to time. The 1990s and early 2000s was a period of declines in US born scientists and engineers. Foreign-born students largely filled this gap until security concerns in the aftermath of 9/11 imposed visa restrictions. These restrictions have since loosened.

Enrolment in science and engineering programmes has increased at the undergraduate and graduate levels among US citizens and permanent residents. The rate of increase for the 2009-2010 period is somewhat less (2%) than it was for the 2007-2008 and 2008-2009 periods (2.5% and 3.1% respectively). Graduate science and engineering enrolment among foreign students (i.e., temporary visa holders) was up by 1.7% from 2009-2010 and 35% higher in 2010 than in 2000. In addition, post-doctorate positions increased by 8% from 2009-2010, with the rate higher among US citizens and permanent residents (12.3%) than temporary visa holders (4.4%) (Kang 2012). The unemployment rate has been higher among computer science and life science fields and lowest among graduates in engineering fields (National Science Board 2012). There are no specific national policies to steer students to particular fields to address market demand. Some states offer special scholarships to students entering science, technology, engineering, or mathematics fields. In addition, H-1B visas offer immigration opportunities for workers who can meet labour demands in certain specialty areas. In general, however, the US relies on market mechanisms to match supply and demand.

Formal programmes in entrepreneurial education have been promulgated in recent years, most commonly in business schools. The Kauffman Foundation's has furnished €16m ($20m) to nine universities for entrepreneurship curriculum development, research into entrepreneurship, facilities construction, technology tools, mentorship networking, and expansion of activities into liberal arts programmes. In addition, technical fields are increasingly incorporating "soft" skills such as team-based project work, communication and presentation opportunities, and creativity and problemsolving skills. These are emphasized in the National Academy of Engineering's The Engineer of 2020: Visions of Engineering in the New Century (2004) (National Academies 2004). Although the US educational system requires that curricula meet certain criteria, it also allows for flexibility to accommodate the need for these types of skills.

2.5 Evolution towards the national R&D&I targets

The US does not have an explicit national target for Business Expenditure on R&D (BERD). Business R&D expenditures declined by 0.1% from 2010-2011 compared to a 4% growth for GDP. The effect of the economic downturn has been to orient business R&D expenditures more toward development than basic research. Development expenditures as a percentage of all business R&D were moving downward from 76% in 2005 to 74% in 2007, but have moved slightly upwards in 2008, to 75%, and 76% in 2011. The economic downturn has been a major barrier, as firms increasingly must link research investments to profits.

US R&D policy to foster public and private R&D investment takes place in a bottom-up manner at the national and state levels. Policy for **stimulating greater R&D investment in R&D performing firms** occurs at the national level, through the Research and Experimentation Tax Credit (which is a temporary tax credit first established in 1981 and re-authorized periodically to address its expiration), and at the state level through various state R&D tax credits. The current extension expires at the end of 2013.

The establishment of new indigenous R&D performing firms is supported mostly at the state level through a diverse mix of state and local programmes including incubators, entrepreneurship training, seed capital and angel funds, and business plan reviews. Certain federal agencies play a role in R&D start-up creation, such as the US Small Business Administration (which supports a network of small business planning specialists) and the US Economic Development Administration (which provides funding for economic development infrastructure including incubator facilities).

Stimulation of firms that do not perform R&D (but may in the future) takes place through business assistance programmes such as the US Manufacturing Extension Partnership which works with existing small and medium-sized manufacturers to enhance their competitiveness.

Attraction of R&D-performing firms from abroad takes place at the state level through state commerce departments, which typically offer site location services and tax credits and workforce training assistance.

Cooperative extramural R&D between private and public sectors is supported in various programmes at the federal level such as the US National Institute of Standards and Technology's (NIST) Technology Innovation Programme (TIP) and the NSF's Grant Opportunities for Academic Liaison with Industry programme. In addition, several research centres of excellence such as the NSF's Engineering Research Center (ERC) programme encourage joint industry-university research, even though these centres do not provide funding for the industry portion of such activities. This type of joint activity also is prevalent at the state level through for example joint company-university research grants, many of which are targeted to fields that are of strategic importance to the particular state's economic development activities.

Efforts to **increase R&D in the public sector** are supported through the America COMPETES Act to double the budgets of the US Department of Energy's basic science activities, many of which are performed by the National Energy Laboratories, and also double the budget for NIST's research laboratories. Budgetary sequestration has resulted in a backing off of these efforts to increase public R&D.

Policy mixes towards private R&D investment tend to emphasise tax credits and basic research funding (going to universities and government laboratories) rather than direct funding of industry. This emphasis reflects the longstanding hesitancy at the national level to foster industrial policy. This notion implies that commercial innovation is the responsibility of the private sector, assisted by universities and government laboratories, and not managed by the federal government for example by targeting and favouring certain industries.

The relatively weak relationship between research policy and innovation, given the federal government's reluctance to foster industrial policy, can be seen in the lack of simple, highly coordinated and targeted national levels programmes to promote R&D. One study identified more than 750 programmes that are relevant to small and medium-sized manufacturers (Shapira et al, 1997). However, federal research agencies increasingly have aspirations and expectations concerning the commercialisation of federally-funded research by the private sector. At the same time, evaluation of research and innovation programmes occurs through a networked approach including diverse agencies and methods such as review and coordination through the Office of Science and Technology Policy, Office of Management and Budget assessment, congressional oversight, and agency self-funding of peer review and programme evaluation. Although there is no formal benchmarking systems for programme-by-programme evaluation, the US National Science Foundation publishes Science and Engineering Indicators which includes country comparisons of research and commercialisation output.

The US does not have a centrally coordinated innovation procurement policy. The Office of Management and Budget runs the Office of Federal Procurement Policy, which helps operate federal policies spending by federal agencies yearly on mission-related materials, supplies and services. Several associated harmonising organisations - such as the Chief Acquisition Officers Council (CAOC), Federal Acquisition Institute and the Defence Acquisitions University – help with information sharing and training for public procurement workers. The Defence Department manages the Office for Acquisition, Technology and Logistics (and comparable offices in the service branches). This office was created to assess defence-related technologies. The contracting out of government functions, including R&D functions, has been part of a trend toward privatising public sector services. The idea behind this privatising is to promote private sector efficiencies. There has been an increase in R&D and management and operations (M&O) contractors for the national laboratories, termed government owned contractor operated (GOCO).

Although the US does not have an official policy to use public procurement to promote private R&D, there are a few programmes that use public procurement in this manner, such as SBIR and health information technology (in the Health Information Technology for Economic and Clinical Health Act of 2009). This is also the case with defence procurements; defence procurement of transistors and aircraft has been important in stimulating the semiconductor and aerospace industries. In addition, DARPA support for an early packet-switched network has been considered a precursor to the Internet (OECD 2011). For the most part, however, public procurement is not aimed at this effect.

The US legal and regulatory framework is thought to be relatively innovation-friendly. This environment allows for ease of company start-up and failure, and supports private capital accumulations (through for example, seed capital funds and tax credits at the state level), labour market mobility, and relatively favourable tax rates. The intellectual property system is systematically enforced. Eco-innovation has had various periods of greater support in recent years, such as through the American Recovery and Reinvestment Act of 2009, which provided €8.5b ($10.5b) in the bill for energy efficiency projects for local, state, and federal buildings and €231m ($300m) for purchasing low emission vehicles.

2.6 KNOWLEDGE DEMAND

This section focuses on structure of knowledge demand drivers. Demand for research-based knowledge is proxies by the expenditure of firms on R&D by sector. Manufacturing accounts for two-thirds of all private R&D expenditures in the US, with services comprising the remaining third. The largest sectors based on R&D expenditures are computer/electronic products (20%), chemicals (19%, of five-sixths of which is comprised of pharmaceuticals and medicine), transportation (17%, seven-tenths of which is comprised of aerospace products and parts), and software publishers (9%) If one compares these percentages with the structure of the US economy, one observes a very different pattern. Manufacturing accounts for only 13% of all private sector value-added, with computer/electronics comprising 2% of value-added, chemicals 2%, and transportation 1%.

The services side of the US economy shows a varying pattern of knowledge-demand and sectorial allocation of value added. Service producing industries account for 60% of US private sector value-added. The finance/insurance/real estate sector accounts for 23% of the US economy but only 0.7% of R&D expenditures. Professional business services is a relatively balanced sector in terms of its demand for R&D and sectorial allocation of value-added. Professional business services comprise 16% of total R&D business expenditures. It also accounts for 14% of private sector value-added (Wolfe 2012, Bureau of Economic Analysis 2013). Thus, the relationship between knowledge demand and sectorial economic importance varies, and the sectors with the highest R&D expenditures (with the exception of professional business services) are not always the largest in the economy.

2.7 KNOWLEDGE PRODUCTION

The production of scientific and technological knowledge is the core function that a research system must fulfil. While different aspects may be included in the analysis of this function, the assessment provided in this section focuses on the following dimensions: quality of the knowledge production, the exploitability of the knowledge creation and policy measures aiming to improve the knowledge creation.

2.7.1 Quality and excellence of knowledge production

The US has the largest and most influential national research system. This system is supported by €106.9b ($133.7b) in government funding for R&D in fiscal year 2013. There are 108 higher educational institutions that are doctorate-granting institutions with very high research activity and many of these institutions are prominent in global rankings of universities. There are 41 federal laboratories that conduct research and roughly 5.5m employees in science and technology positions. In terms of output, the US has long been a leader in publication productivity, but since 1995 the US share of published articles has dropped from 34% in 1995 to 26% in 2009, as other countries, primarily in Asia, have had high annual growth rates. The US still maintains its position as having the largest number of highly cited articles. In terms of patenting, the number of invention disclosures recorded with the university technology licensing offices increased by more than 40% from 2002 to 2009 and patent applications by more than 70% (National Science Board 2012).

2.7.2 Policy aiming at improving the quality and excellence of knowledge production

The quality and excellence of knowledge production is based on several mechanisms at the institutional, departmental, research group (if funded), and individual levels. Accreditation standards are applied to university institutions and departments. Research group funding proposals are subject to external review of peer scientists, funded projects must submit annual reports of progress, and larger centres go through visits and review by programme managers and peer scientists. There has been concern that "earmarks," which designate moneys in appropriations bills for certain research projects in an elected official's jurisdiction, by-pass the formal research quality system of peer review; however, since the congressional ban on earmarks, these mechanisms have been less used. The US does not have research institution assessment mechanisms that allocate national funding to institutions because higher educational institutions in the US are not centrally chartered. Review of government-sponsored national laboratories typically occurs by the agency under which these laboratories are organised; there is no national assessment mechanism for these laboratories taken together as a single system.

2.8 KNOWLEDGE CIRCULATION

2.8.1 Knowledge circulation between the universities, PROs and business sectors

Policy measures reinforcing the cooperation between universities, research and business fall into three categories. First, technology transfer legislation such as The University and Small Business Patent Procedure Act (Bayh–Dole Act, Public Law 96-

517) and the Stevenson–Wydler Technology Innovation Act, (Public Law 96-480) which are designed to foster technology transfer between universities and companies (in the case of the Bayh-Dole Act) and federal laboratories and companies (in the case of the Stevenson-Wydler Act). Timelines show significant increases in university patenting since the passage of the Bayh-Dole Act, although studies have suggested that other factors, such as the emergence of the biotechnology industry, maybe more of a factor (Mowery et al 2001).

The second type is the university-industry consortium. The Engineering Research Centre (ERC) programme is an example. This programme seeks to transform engineering education by encouraging the creation of cross-disciplinary university-based industry consortia around breakthrough research areas. An ERC typically receives roughly €1.6m ($2m) a year in federal funding and there are 17 ERCs as of June 2012 organised around four knowledge clusters: manufacturing; biotechnology and health care; energy and sustainability; and microelectronics, sensing and information technology. Evaluations of these programmes find positive effects on university education and mechanisms for industry engagements, although intellectual property issues and challenges in communicating tangible evidence of outcomes remain. (Feller et al, 2002) The structure and requirements for ERCs have evolved such that a third generation (Gen-3) wave has been promulgated to give more importance to innovation and entrepreneurship, partnerships with small research firms and international collaboration and exchange.

The third type of knowledge circulation measure is business and technical assistance services. One of the earliest of these types of services is the Cooperative Extension Service (CES) in the US Department of Agriculture. The CES was established to transfer research results from the university to farmers through the cooperative extension agent. The US Manufacturing Extension Partnership (MEP) draws on this tradition with an innovation and technology orientation to transferring knowledge about the latest production technologies and techniques to small and medium-sized manufacturers. The MEP budget has fluctuated around €80m ($100m), although budgets during the Obama administration were €102m ($127m) in 2013. The MEP programme has been found to be generally effective in transferring pragmatic technologies and techniques. For the past several years it has undergone a strategic re-orientation in its service offerings to place greater emphasis on new product development, innovation and technology adoption (Shapira et al, 2011).

2.9 OVERALL ASSESSMENT

The US system's size, private sector innovativeness, and large number of high quality research universities make it a large and attractive location for research and innovation performance. Recent indicators such as scientific suggest that the traditional leading position of the US in academic research is less prominent than it once was, challenged by the rising output from China and other Asian countries. Moreover, the flexibility and decentralisation of the US system which is supportive of innovation, entrepreneurship and labour mobility also limit coordination, highlighted in recent years, in the difficulties in producing timely budgets and other types of important legislation. These difficulties are increasingly recognized in global competitiveness rankings and credit ratings and they add uncertainty to the research and innovation process.

3 National policies for R&D&I

3.1 LABOUR MARKET FOR RESEARCHERS

3.1.1 Stocks of researchers

The US has about 5.4m employees in science and engineering occupations or 1.8% of the total US population. More than 30% of these science and engineering workers perform R&D as a major work activity, with nearly 80% of those in the private sector spending at least 10% of their time on R&D. Unemployment rates for science and engineering employees from 1983 to 2010 ranged from 1.3% to 4.3% compared with the 4% to 9.6% unemployment rate for all workers. In 2009, these figures were 4.3% for science and engineering employees compared to 9.3% for all workers. As a result of the economic downturn, unemployment rates for all US employees were continuing to rise but for science and engineering workers, these rates levelled and were dropping (National Science Board 2012).

The US has long been a relatively attractive destination for researchers. Its share of foreign students has experienced recent declines, however, dropping from 25% in 2000 to 20% in 2009. At the same time, the US continues to be the most frequent location for undergraduate and graduate students, with nearly 600,000 foreign tertiary education students in 2010. Nearly 25% of US doctoral students are from outside the country. However, the share of foreign postdoctoral students is much higher in that nearly half of US postdoctoral students are foreign.

The US also has a comparatively small number of students that study outside the country. There are 52,000 US tertiary students at a higher educational institution outside the US, roughly one-twelfth the size of the foreign students studying in the US.

3.1.2 Providing attractive employment and working conditions

Science and engineering employees earn more than twice the salaries of the average (median) worker. US science and engineering salaries are representative of what is found in developed countries. Some US companies look to lower cost countries for research workers based on factors such as reduced personnel costs as well as access to larger talent pools and market entry. There are no national salary specifications for R&D employees in universities and private non-profit research institutes (although agencies such as the National Institutes of Health can specify pre-doctoral and postdoctoral stipend levels in its fellowship awards), as well as in private sector companies, so these organisations have the flexibility to make decisions based on market factors.

The federal government has a pay system – the General Schedule – comprised of grades, steps within grades, and pay factors that vary depending on the location of the work. The salary levels are based on national compensation surveys.

The Family Medical Leave Act allows employees of government research institutes and companies with 50 or more workers to take unpaid leave and retain their jobs. There are no national policies or regulations promoting equal gender representation in academic and research committees, boards and governing bodies. These types of considerations are typically accounted for as part of the informal norms of university operations and governance.

Periodically, concerns have been raised as to whether there are sufficient numbers of science and engineering workers. One of the earliest results of these concerns was the National Defence Education Act, which was enacted in the 1950s in the wake of the launch of the Sputnik programme. This legislation offered incentives for science and engineering degrees. Similar concerns were expressed in the mid-2000s and resulted in sections of the America COMPETES Act promoting educational opportunities, scholarships, and teacher training in the science, technology, engineering, and mathematics fields from early educational levels through graduate school. At the same time, the correspondence between supply and demand is not complete because of uncertainties in the extent of company hiring during the economic downturn. In addition, students have the freedom to pursue certain jobs or educational fields for reasons of their own, such as to earn higher salaries, have a greater likelihood of landing a job, offering a better fit with skills, and various lifestyle factors (e.g., wanting to live in a certain city, desiring jobs with certain working conditions). (Drummond and Youtie 2003)

3.1.3 Open recruitment and portability of grants

Non-nationals are eligible for academic positions subject to visa requirements and availability of these positions. Except for fulfilling visa requirements, there are no examinations that universities or research institutes require of non-nationals. Foreign academic degrees are generally recognised as equivalent to the extent that they correspond to the standard doctoral degree, for example. International advertising of research vacancies may occur, typically through the disciplinary society of the department in which the vacancy resides.

The portability of research grants is subject to the rules and regulations of the agency that awarded and administers a grant. For example, if an NSF principal investigator leaves for another institution and both the old and new institution agrees, the grant can be moved to the new institution. The principal investigator completes an NSF grant transfer request form to promulgate this transfer and move unspent funds to the new institution.

3.1.4 Enhancing the training, skills and experience of researchers

The US educational system has standard norms and practices for doctoral education. US doctoral education (which is conducted in English except for language requirements and specialisations), typically involves coursework, field examinations, oral defences of the dissertation, and a written dissertation. The postdoctoral programme is more flexible, which has not always provided for the best research experiences. In accordance with the American COMPETES Act, the NSF adopted procedures for formal mentoring of postdoctoral researchers. All grants that include funding for postdoctoral education must have an explicit mentoring plan. The mentoring plan includes requirements to provide career advice, assistance with publication and patent development, assistance with grant proposal development, and teaching experiences.

The US labour system, including the research sector within this system, is very flexible and allows for mobility through the career trajectory. This system allows for both staying at the same academic institution throughout the career and moving from institution to institution. A recent study of highly creative researchers in the US and Europe did not find that institutional mobility was significantly associated with highly creative research among US researchers, although it was for European researchers. However, mobility across disciplines was positively associated with highly creative research in the US although not in Europe (Youtie et al, 2012).

3.2 RESEARCH INFRASTRUCTURES

The US does not have a national research infrastructure roadmap. NSF estimates that about €1.6b ($2.0b) was spent on research infrastructures at universities. Funding from the federal government supported 55% of this infrastructure. The largest area of federal funding for research infrastructure at academic institutions is the life sciences, followed by engineering and the physical sciences. Funding for academic research equipment rose by 2% from fiscal years 2008 to 2009 but declined by 9% in constant dollars from 2004 levels. (National Science Board 2012)

At the government research laboratory level, the US Department of Energy (DOE) operates the largest system of national laboratories. DOE laboratories account for 16 of the 41 national laboratories and research centres in the US. Although the DOE system is not the only system of government research laboratories in the US, its importance is notable. DOE spent €594m ($743m) facilities budget in fiscal year 2013 on R&D facilities, including the laboratories. This figure represents a 17% decline in facilities spending over the prior year budget (AAAS 2014).

3.3 STRENGTHENING RESEARCH INSTITUTIONS

3.3.1 Quality of National Higher Education System

The US has 4700 tertiary-level institutions. Nearly 21 million students, which equates to nearly 7% of the US population, enrolled in higher educational institutions in 2011. The US system includes public universities, governed by US states, and private universities which may be non-profit or for-profit, with the latter typically involved in skill acquisition rather than research.

In the 2011-2012 period, 3.6 million student graduated from higher education. 41% of graduates are male and 59% are female. In 2011-2012, nearly 5% of graduates received doctoral degrees. Males accounted for 48% of these degrees. The distribution of degrees across fields indicates that business accounted for 21% of bachelor's degrees, followed by humanities at 17% and social sciences at 16%. Master's degrees were most prevalent in business and education fields, each comprising more than one-fourth of all master's degrees. Nine percent of doctoral degrees was in the natural sciences (US Department of Education 2013).

More than 720,000 non-US students enrolled in US HEIs in the 2010-2011 period. Regions with the largest share of non-US student enrolees at US HEIs were Asia (30%), Middle East (26%), Latin America (16%), Africa (12%) and Europe (9%) (US Department of Education 2013).

Higher educational institutions perform more than 15% of US R&D. Academic R&D grew by 4.8% from 2010-2011, down from the 5.8% growth rate for 2009-2010. Private sector support accounts for 5% of all academic R&D funding sources in the US, with the federal government representing the largest funder of university research (61%).

Higher educational institutions share certain missions - the edification of an informed citizenry - and possess distinctive missions that are reflected in organisational arrangements and affiliation, degree offerings, and typical student. Community colleges emphasise the educational mission in a preparatory mode for future enrolment to university, as a passage between high school and university, and as a training source for jobs that entail some post-secondary educational training. Public universities, governed by state, tend to emphasise service and economic development missions, especially state land-grant universities, which were originally created to foster practical subjects and the application of research to the local economy. Doctorate-conferring degree universities' missions stress high levels of research. The Carnegie Classification system for higher educational institutions is widely used in the US to classify HEIs according to their research activity and degree awards as a proxy for the institutions' mission. One hundred and eight HEIs have been classified as doctorate-granting institutions with very high research activity. These institutions tend to be the most selective, requiring high grade point averages and college entrance examination scores.

Although the US does not have a national research assessment exercise, academic research performance metrics are monitored. These research performance metrics typically place the US at the top in terms of publications, patents, and attraction of foreign students. As previously indicated, the US authored 26% of Science and Social Science Citation Index papers, the largest after the European Union. Ten-year growth rates are much lower for the US (at 1.0%) and EU member countries (1.4%) than for Asia in general (8.9%) and China in particular (16.8%). Co-authorship with researchers in other countries is on the rise in the US, representing 32% of all US papers in 2009, up from 23% in 2000. The largest European publishing countries have around 50% or more co-authored publications, while China's international collaboration rate stayed about the same at approximately 27% (National Science Board 2012). In addition, the US has the largest number of foreign students. In the Shanghai Academic Ranking of World Universities (2012), eight of the top 10 and more than half of the top 100 are American universities. By field of excellence, American universities comprise seven of the top 10 in natural sciences, 10 of the top 10 in engineering/technology and computer science, nine of the top 10 in life and agricultural sciences, nine of the top 10 in clinical medicine and pharmacy, and 10 of the top 10 in social sciences.

US universities are subject to multifaceted quality assurance mechanisms at the institutional, departmental, research group, and individual levels. These include accreditation standards by external certifying organisations, auditing and certifications of external research costing standards, scientific peer review of research proposals, external scientific review of large research centres, blind review of academic paper submissions, and human and vertebrate subjects training and protocol review (by the university's Institutional Review Board) to ensure that ethical and responsible research performance is understood and practiced.

3.3.2 Academic autonomy

The US academic system generally supports academic autonomy within certain limits. Regarding teaching decisions, there are required courses that must be taught and departmental permission is usually needed to offer elective courses. Researchers typically have autonomy to pursue research fields of interest. However, this pursuit is subject to considerations such as the types of journals that the researchers' departments prioritise and the areas of funding that federal and other types of sponsors provide. Research decisions are subject to the areas in which funding is available.

The appointment of university leadership often occurs through an explicit hiring process in which candidates are screened and public presentations are made. In addition, internal conflicts are managed through a specific procedure often spelled out in faculty and student handbooks and institutional statutes, and promulgated through various committees and assemblies. Faculty participation in these committees and assemblies is part of their service role.

In terms of financial autonomy, public institutions are subject to tuition and fee decisions made at the state university system level. In contrast, private institutions have similar types of organisations such as boards of directors that engage in these types of financial and management policy-setting. However, there are financial practices that both types of institutions must follow. For example, both types of institutions must adhere to federal government rules and regulations about what facilities and administrative fees these institutions are allowed to charge for conducting federal research. Institutional funding, which primarily comes from gifts to the university by alumni and other benefactors, provide greater financial autonomy and are often used to construct buildings for research and educational purposes. Within these restrictions, and coupled with the lack of centralised chartering at the national level of colleges and universities, the US system does allow for a measure of academic autonomy and this autonomy does from time to time lead to debates about the extent to which academia should be more separated from society or more integrated with it (Fish 2004).

3.3.3 Academic funding

The US system does not offer national block funding on the basis of national performance assessments. State-funded public universities include funding for teaching, public service, research, and buildings/equipment/infrastructure (i.e., capital investment). These allocations vary from state to state and are not based on scientific indicators such as scholarly publications or patents. Among highly research-intensive institutions, state funding may account for a minority of the university's total budget, with other sources such as federal research awards and institutional giving. The National Science Foundation's Survey of Research and Development Expenditures at Universities and Colleges reports that federal research awards accounted for 59% of university budgets, institutional giving 20%, state and local government 7%, and industry 6% in fiscal year 2010 (Britt 2012). Universities can make decisions for allocating some of their resources autonomously such as returned overhead from research grants or alumni gifts and contributions that have not been allocated to certain development projects.

3.4 KNOWLEDGE TRANSFER

3.4.1 Intellectual Property (IP) Policies

Universities and public research organisations' intellectual property policies are guided by the aforementioned Bayh-Dole and Stevenson-Wydler Acts. Under the Bayh-Dole Act, the university retains title to government funded research and licensed to companies, with the US government keeping a royalty-free license to use the intellectual property. Similar provisions apply to public research organisations under the Stevenson-Wydler Act. Researchers (including students and faculty) must disclose intellectual property developed with federal funding to an intellectual property office. After reviewing the disclosure form, the university may elect to file a patent application if the intellectual property has sufficient market potential to justify patent filing expenses. The resulting intellectual property may warrant commercialisation as a separate company or be licensed to an existing company. If it is licensed, the university will market the intellectual property and negotiate with interested companies. Many companies seek flexible contracting procedures, so some universities have in place open source collaboration and other types of mechanisms if there are no other obligations that preclude these types of arrangements.

There are incentives for the pursuit of intellectual property which vary by university. A typical pattern for sharing intellectual property revenues is to divide them across the institution, the individual inventor, and the inventor's department. Although 20 years ago, patenting was not as much considered in promotion and tenure decisions, today it is usually taken into account.

Management of conflicts of interest occurs through annual disclosures, disclosures when conflicts occur, and research proposal submission and contract reporting. It is against the law for university personnel to engage in activities that result in a significant financial interest.

Intellectual property offices are usually staffed by attorneys skilled in technology transfer review, management, and negotiation. These organisations undertake professional development through professional societies such as the Association of University Technology Managers (AUTM). AUTM produces publications that summarise licensing activity, salary information, and legal issues. These offices are often funded in part with university licensing royalties depending on the size of the royalties at the university. Some universities also receive a percentage of equity ownership of university spin-offs whereas others do not.

3.4.2 Other policy measures aiming to promote public-private knowledge transfer

Spinoffs

Support systems to facilitate knowledge transfer, university spinoffs, and venture capital and angel financing investment typically reside at the state, local (i.e., city), and university level rather than at the national level. Not all universities have programmes to promote spin-offs though many do. For example, the Southern Growth Policies Board's *Innovation U* report lists 12 universities with very strong public-private knowledge transfer organisations and programmes. Culled from a list of 164 nominated universities, the 12 top universities profiled in the report were described as having best-in-class programmes or organisations in entrepreneurial development and other types of public-private knowledge transfer. Typical entrepreneurship activities that can be found at these universities include Activities may include incubation, seed fund management, assistance with SBIR grants, entrepreneurship education, and networking events such as venture forums (Tornatzky et al 2002). Incubators based at US universities appear prominently in global incubator ratings; nine of the 25 top listed global incubators by the Sweden-based University Business Incubator Index are at US universities (UBI 2013).

Inter-sectoral mobility

There are no legal restrictions, except for conflict of interest restrictions, in private sector researchers moving into academia. Mobility from industry to the universities is supported through multiple means. Hiring of industry experienced researchers is not uncommon at universities. Many universities have "professors of practice" who teach courses and perform service and sometimes research functions that explicitly draw on the private sector experience of the person. Adjunct professor positions are frequently found in departments that seek to leverage private sector experience to fill instructional voids. The reverse is less common, but does happen for example when a professor leaves academia to work in his or her spinoff company or to work in a large company which may have licensed his or her technology. Going back and forth between sectors is difficult. However, universities allow for sabbaticals which can facilitate faculty taking visiting positions with companies as well as with other universities.

Promoting research institutions - SME interactions

SME interactions with research institutions are diverse and many are supported through federal programmes. The US Manufacturing Extension Program, which uses industrially-experienced specialists to help small and medium sized manufacturing enterprises maintain competitiveness, has many centres situated at universities. The US Small Business Administration runs the Small Business Development Centers (SBDC) programme through university partners which assist small start-up companies with business plan creation. The US Department of Agriculture's Cooperative Extension Service has extension agents at universities which transfer research and best practices to small as well as large agricultural establishments. These federal programmes are run in partnership with state governments.

Involvement of private sector in the governance bodies of HEIs and PROs

Industry advisory boards and councils are common in universities and research organisations. They may be established at the institution level and/or the department or programme level. These boards and councils often perform a strategic visioning role to guide curriculum development or other university offerings. Mutual learning often takes place as these company representatives have the opportunity to learn about university or research organisation activities.

Regional Development policy

The US does not have a formal regional cohesion or development policy. State governments typically manage regional development programmes. However, the US Economic Development Administration does provide funding support for incubator, science parks, and other types of economic development facilities and infrastructure. The funding typically runs through a regional office of the Economic Development Administration and in accordance with the comprehensive plan of a regional development district. State technology-led economic development programmes usually are based on the distribution and management of grants to state institutions and sometimes companies. By way of illustration, the Ohio Third Frontier and related programmes, administered by the Ohio Department of Development, include pre-seed funds for investing in technology start-ups, action and grant funds to support applied R&D leading to commercialisation, and a capital fund to support venture capital for R&D in science and technology based entrepreneurial firms in the state. Third Frontier programme moneys are distributed to different regional entities based in part on competitive proposals and in part on the desire to balance regional development opportunities. Funding for the Third Frontier programme came from "tobacco settlement funding" (the Tobacco Master Settlement Agreement between the US states and four largest tobacco companies to address tobacco-related health liabilities) and a bond issuance approved by Ohio voters.

3.5 ASSESSMENT

The US research institution system includes many US universities with have a solid reputation which places them at the top of global rankings. This research system is underpinned with a large stock of science and engineering researchers. Concerns have been raised about whether this stock is sufficient over the long term given the fast pace of technological change (Executive Office of the President 2009, 2011). Still, the flexibility and autonomy of the labour system in academia and the private sector makes it globally attractive.

Gaps in the research enterprise remain, however. A 2012 report by the National Research Council highlights the uncertainty in university research funding streams as a result of recent declines in state and federal budgets. Concomitant increases in university tuition have raised questions about the value of a university degree in the current tight job market. Although private sector firms and universities have good albeit limited relationships, there is an opportunity for universities to fill the transformational role left by the decline of large corporate laboratories. Stable funding, greater autonomy and cost-effectiveness, improved graduate programmes, and greater attention to international students and scholars are among the action items suggested to address these issues (National Research Council 2012, see also President's Council of Advisors on Science and Technology 2012).

4 INTERNATIONAL R&D&I COOPERATION

4.1 MAIN FEATURES OF INTERNATIONAL COOPERATION POLICY

US participation in R&D&I cooperation recognises that R&D&I operate in a global enterprise. US science and technology aims to cooperate on international efforts to shape the standards of scientific practice. Fostering good will, reinforcing political relationships, furthering democracy and civil society, and moving the frontiers of knowledge forward are other indirect objectives of US participation (US Department of State 2012).

A primary instrument for US R&D&I cooperation is the bilateral and multilateral science and technology agreement. These agreements are guided by the principles of sustainable development, respect for the role of women, worldwide security, science-based decision-making, and good governance, which OECD defines as "participation, transparency, accountability, rule of law, effectiveness, equity… the management of government in a manner that is essentially free of abuse and corruption, and with due regard for the rule of law" (OECD 2006).

The US State Department indicates several areas of collaboration in international science and technology cooperation. These areas correspond to societal challenges. They include: "agricultural and industrial biotechnology research (including research on microorganisms, plant and animal genetic materials, both aquatic and terrestrial), health sciences, marine research, natural products chemistry, environment and energy research" In addition, security responsibilities to protect information and technology transfer are main concern (US Department of State 2012).

4.2 NATIONAL PARTICIPATION IN INTERGOVERNMENTAL ORGANISATIONS AND SCHEMES

The US participates in a range of forums in the science and technology domain sponsored by OECD, USAID, UNESCO, and the like. US participation is also frequent in standards-setting activities relating to science and technology through the International Organization for Standardization (ISO). The Association for the Advancement of Science (AAAS) serves as a frequent host organisation for science and technology forums held in the US. Recent examples include International Symposium on Assessing the Economic Impact of Nanotechnology, and joint programs with the EU on commercialization, cluster mapping, and transatlantic R&D collaboration.

The US participates in several large-scale research infrastructure programmes even though it does not have a national strategy for such participation. The US has special observer status in the European Organisation for Nuclear Research (CERN). The US contributed to accelerator construction costs of CERN's Large Hadron Collider and has a large number of users because of the uniqueness of the accelerator for particle physics. The US was a founding partner, through the National Aeronautics and Space Administration, in the International Space Station with the goal being that a platform for space research would exist. The US participates in the Integrated Ocean Drilling Programme (IODP) to investigate seafloor environments through the National

Science Foundation, alongside Japan's Ministry of Education, Culture, Sports, Science and Technology; The European Consortium for Ocean Research Drilling; The People's Republic of China Ministry of Science and Technology; the Interim Asian Consortium; the Australian-New Zealand IODP Consortium; and the India Ministry of Earth Science. Various US universities have partnerships in international research infrastructure initiatives. The Southern African Large Telescope has had US involvement since 2004 through the University of Wisconsin-Madison and other universities (Dartmouth, Rutgers, and University of North Carolina at Chapel Hill) and the American Museum of Natural History (since 2007). The University of Florida has been a member of the Gran Telescopio CANARIAS since 2008.

4.3 COOPERATION WITH THE EU

4.3.1 Participation in EU Framework Programmes

The US does not have a national strategy concerning participation in EU Framework Programmes.

Table 1: United States Participation in FP7

		All submitted		Mainlisted			Success Rate: applicants in mainlisted proposal / applicants in all submitted proposals - applicants from United States
Proposal SP Description2	Proposal Program	Number of Proposals	Number of Applicants	Number of Proposals	Number of Applicants	Proposal Total Cost	
CIP	CIP-ICT-PSP	8	9	2	2	693,000	22.22%
Not_Available	N/A	11	11				
SP1-Cooperation	ENERGY	55	64	17	20	163,602,118	31.25%
SP1-Cooperation	ENV	132	166	33	44	240,113,625	26.51%
SP1-Cooperation	HEALTH	368	465	94	120	806,411,338	25.81%
SP1-Cooperation	ICT	598	663	88	116	485,204,038	17.50%
SP1-Cooperation	KBBE	180	237	44	62	280,897,777	26.16%
SP1-Cooperation	NMP	118	189	30	50	209,169,209	26.46%
SP1-Cooperation	SEC	46	63	10	15	95,754,060	23.81%
SP1-Cooperation	SP1-JTI	15	15	2	2	72,158,131	13.33%
SP1-Cooperation	SPA	99	134	19	27	61,945,828	20.15%
SP1-Cooperation	SSH	81	93	7	8	47,091,451	8.60%
SP1-Cooperation	TPT	63	69	18	20	123,336,325	28.99%
SP2-Ideas	ERC	284	357	14	18	21,198,178	5.04%
SP3-People	PEOPLE	3,032	3,170	772	841		26.53%
SP4-Capacities	INCO	18	24	5	9	7,253,790	37.50%
SP4-Capacities	INFRA	61	88	27	43	218,172,986	48.86%
SP4-Capacities	REGIONS	1	1				
SP4-Capacities	SiS	36	42	11	13	21,142,912	30.95%
SP4-Capacities	SME	23	23	2	2	5,219,863	8.70%
SP5-Euratom	Fission	13	15	7	7	72,831,158	46.67%
	Sum:	**5,242**	**5,898**	**1,202**	**1,419**	**2,932,195,787**	**24.06%**

Typically participation is based on decisions of individual or groups of researchers. Through April 2013, US participants were involved in 5,242 FP7 proposals of which 1,419 or 24% were awarded (Tables 1 and 2). These grants represented €2.9b. By number of proposals, SP-3 PEOPLE awards comprised 60% of all successful FP7 proposals with US involvement. By budget size, grant awards with US involvement in SP-1 were largest in the health field, which comprised more than one-quarter of FP7 funding. The ICT field accounted for 17% of SP-1 award amounts with US involvement. Success rates in proposals with US involvement were relatively higher in Fission, Infrastructure, International Cooperation, Knowledge Based Bio Economy, Environmental, and Health. By type of project, Marie Curie fellowships comprised more than half of proposals submitted and awarded with US involvement. Collaborative projects ranked second, comprising more than 30 percent of proposals.

Table 2: Contract type of the FP7 projects with United States participation

Proposal Sub Funding Description	Number of Proposals submitted	Number of Proposals mainlisted
CIP-Pilot Type A	1	1
CIP-Thematic Network - ICT	4	1
Collaborative project for specific cooperation actions dedicated to international cooperation partner countries (SICA)	58	8
Collaborative project (generic)	147	37
Collaborative Project targeted to a special group (such as SMEs)	28	6
Combined Collaborative Project and Coordination and Support Action	4	1
Coordinating action	167	45
ERC Advanced Grant	99	4
ERC Starting Grant	175	8
Industry-Academia Partnerships and Pathways (IAPP)	26	7
Initial Training Networks (ITN)	87	9
Integrating Activities / e-Infrastructures	38	17
International Incoming Fellowships (IIF)	42	12
International Outgoing Fellowships (IOF)	2,654	621
International Research Staff Exchange Scheme (IRSES)	221	123
Joint Technology Initiatives - Collaborative Project (FCH)	8	1
Joint Technology Initiatives - Coordination and Support Action (FCH)	1	1
Large-scale integrating project	351	92
Network of Excellence	7	4
Proof of Concept	5	2
Research for Civil Society Organisations (CSOs)	2	1
Research for SMEs	19	1
Small or medium-scale focused research project	620	125
Small or medium-scale focused research project INFSO (STREP)	344	43
Supporting action	103	32
	31	
Sum:	**5,242**	**1,202**

4.3.2 Bi- and multilateral agreements with EU countries

The US has Umbrella Science and Technology Agreements that are in force and active or in the final stages of approval with 54 countries or regions (US Department of State 2010). Umbrella agreements exist with the European Union and 15 member countries: Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Poland, Romania, Slovakia, Slovenia, Spain and Sweden. These agreements provide frameworks for science and technology cooperation, intellectual property protection, research access, and related topics but usually do not indicate explicit fields for cooperation. However, a study by Pals and Wang (2010), as part of the Link2US programme, indicated that the most common area in these agreements is environmental and climate change (in nine of the agreements), followed by energy and health (in eight agreements), and agriculture and basic research (in seven of the agreements).

Implementation of agreements depends on subsequent activity by particular federal agencies. For example, the National Institutes of Health, the National Science Foundation, or other federal agencies award research grants, R&D contracts, and fellowships to researchers from other countries, including EU countries. These awards may be used as instruments for travel to workshops, international comparative research, membership fees in international research organizations, and support for international research facilities and equipment.

Bilateral and multilateral agreements are the main instruments of science and technology diplomacy. As such, they do not indicate preferences for one country over another. Country preferences can be discerned by examining allocations of grant awards at the country level.

4.4 COOPERATION WITH NON EU COUNTRIES OR REGIONS

4.4.1 Main Countries

The US has umbrella Science and Technology Agreements with 38 non-EU countries. These include: Algeria, Argentina, Armenia, Australia, Azerbaijan, Bangladesh, Brazil, Chile, China, Columbia, Croatia, Cyprus, Egypt, Estonia, Georgia, India, Japan, Jordan, Kazakhstan, Korea, Libya, Macedonia, Mexico, Morocco, New Zealand, Norway, Pakistan, Philippines, Russia, Saudi Arabia, South Africa, Switzerland, Tunisia, Turkey, Ukraine, Uruguay, Uzbekistan and Vietnam. These agreements typically address areas of research that are priorities for international science and technology agreement with any country – EU or non-EU - such as research cooperation in science and technology in energy, environment, health, agriculture, and basic research. They also characteristically include provisions to address scientific exchange, intellectual property protection and sharing, taxation, and deal with economic development, security, and stability (US Department of State 2012).

4.4.2 Main instruments

In terms of implementation, common instruments used to implement agreements include research projects, task forces, studies, workshops/symposia/ conferences/seminars, visits and exchanges, and equipment and materials sharing for implementation. Training of scientists and technical experts is also used. However, given that federal agencies the most substantial levels of implementation concern foreign participation in national R&D programmes. Based on a search of agency funding awards, in the case of NSF, the agency awarded €21.7m ($27.1m) a year on average over the 2007-2012 period to investigators outside the US or 0.5% of all moneys awarded through the agency's funding programmes. Over the last 2007-2012 time period, investigators in EU member states received an average of €7.5m ($9.4m) per year of this funding. The top countries in terms of NSF research dollars awarded from 2007-2012 were Austria, Denmark France, Germany, Italy, Sweden and the United Kingdom. The NIH awarded €210.1m ($262.6m) a year on average to investigators outside the US over the same time period or 1.3% of all moneys it awarded through its funding programmes. Of this amount, €51.8m ($64.7m) a year on average went to investigators in EU member states. The top countries in terms of NIH research dollars awarded from 2007-2012 were: Denmark, France, Germany, Italy, the Netherlands, Sweden and the United Kingdom.

4.5 OPENING UP OF NATIONAL R&D PROGRAMMES

The US R&D environment allows for foreign researchers or research teams to move to the US to perform research. It also allows for foreign researchers or research teams to perform US-funded research in the foreign researchers' home countries. Provisions for these allowances can be found in research programme solicitations, which may require a rationale for participation by non-nationals to be submitted along with the research programme application. Indeed, the Link2USA programme conducted a survey of 11 US federal agencies and found 14 funding programmes that were open to EU-based researchers. These programmes are in the US Department of Energy, Department of Homeland Security, Department of Transportation, Environmental Protection Agency, National Aeronautics and Space Administration, National Institutes of Health, National Institute of Standards and Technology, National Oceanic and Atmospheric Administration, National Science Foundation, U.S. Department of Agriculture, and U.S. Geological Survey.

Policies to open up national programmes to foreign countries are not a top tier priority in US science and technology policy. Barriers to opening up national research programmes to participation by non-national individuals primarily lie in visa restrictions. At the country level, barriers for opening up research programmes are tied to national security policy, and the US State Department usually leads decision-making in this area.

4.6 RESEARCHER MOBILITY

4.6.1 Mobility schemes for researchers from abroad

The Fulbright Programme was created after World War II in the Fulbright Act of 1946 (Public Law 584) to support international exchanges between Europe and the US. The programme sponsors scholarships that underwrite research and teaching travel for academics to and from the US at the undergraduate, graduate, post-doctoral, and faculty and administrative levels. In 1961, the programme was extended to include a wider range of funding sources. The programme has since expanded to more than 155 countries according to the US Department of State. Eight thousand scholarships are granted every year. Foreign governments often provide matching funds through binational commissions or foundations, which also provide priorities for grants. Evaluations of this programme find that it promotes ongoing collaboration, provides a better understanding of the country, is judged to be valuable, and attracts interest in applying for a follow-on Fulbright fellowship (US State Department 2013).

One issue is that when researchers from abroad are in the US, they can become isolated from the hosts country's scientific community. The US State Department (through its Office of the Science and Technology Adviser to the Secretary) along with the American Association for the Advancement of Science (AAAS) and the National Academy of Sciences, sought to address this problem in 2012 by creating Networks of Diasporas in Engineering and Science (NODES). NODES connects foreign scholars to US science and technology agencies, science and technology oriented private non-profit organisations, other scholars, and students and entrepreneurs. The US State Department's interest in NODES lies in the notion of diplomacy as a societal matter designed to give acquaintance to US scientific and democratic values such as intellectual merit and systemised review processes. NODES hosts an annual meeting in partnership with the International Diaspora Engagement Alliance (IdEA).

4.6.2 Mobility schemes for national researchers

In addition to the Fulbright Programme, which also sponsors international exchange for US researchers, various agencies will support international exchange. For example, NSF's Office of International Science and Engineering (ISE) supports a range of international research and education activity through supplements to existing grants and through workshops and summer institutes (ISE 2013). Examples of ISE's programmes include:

- International Research Experiences for Students
- Doctoral Dissertation Enhancement (to do dissertation work at a foreign location)
- International Research Fellowship Programme (for recent doctoral recipients to conduct research at a foreign location)
- Pan-American Advanced Studies Institutes (short science and technology courses in Latin America)
- East Asia and Pacific Summer Institutes (research opportunities for graduate students during the summer)
- Partnerships for International Research and Education (institution-to-institution partnerships with a US and non-US HEI)
- Science Across Virtual Institutes (for collaboration between NSF supported centres and international partners)
- International Planning Visits and Workshops

5 CONCLUSIONS

US support for research policy reflects the generally favourable view of the role of the federal government in making science investments. Investment in research that addresses grand challenges is exemplified by health, clean energy, national security, and education. Innovation policy has seen fresh activity in the manufacturing sector, along with continued support for regional innovation clusters and continuing implementation and monitoring of patenting reforms. Education quality is an ongoing concern in the US, although it is primarily the purview of state governments, with the federal government having a limited role with an orientation toward science, technology, engineering, and mathematics (STEM) education. Other policy areas such as climate change are raised from time-to-time, but they are less important compared to economic recovery and federal budget deficit reduction.

	Recent policy changes	**Assessment of strengths and weaknesses**
Research policy	There has been continued pressure to reduce non-discretionary spending but the President's 2014 proposed budget if approved would represent an 8% increase in Federal R&D spending.	Future budgets are likely to undergo reductions that will affect overall amount available for R&D. In addition, legislation has been introduced to eliminate funding for some research programs in the social sciences at the National Science Foundation.
Innovation policy	Advanced manufacturing is a priority, three advanced manufacturing institutes as part of the National Network for Manufacturing Innovation planned for 2013, Manufacturing Technology Acceleration Centers, and a community-level program investing in partnerships between manufacturing, government, and universities.	The US generally has a favourable environment for innovation, particularly the innovativeness of US companies, quality of universities and flexibility of the labour market. (World Economic Forum 2012) However, low ranking in levels of distrust of policy makers, burdens on the private sector, and budgetary and macro-economic instability limit US competitiveness.
Education policy	New programs promote STEM teacher training and certification to produce 100,000 teachers in 10 years, including the National Math and Science Initiative (NMSI) in partnership with the Howard Hughes Medical Institute (OSTP 2013)	Tertiary education continues to be an asset of the US system. Primary and secondary education in the US frequently compares less favourably with international counterparts. State budget shortfalls persist, with less money going to primary and secondary education and steep tuition increases by public universities and colleges prompting public outcry.
Other policies	The National Oceanic and Atmospheric Administration (NOAA) released a five-year R&D plan which places greater priority on climate change and sustainability.[4]	Although the US has strong programmes in the energy and environmental areas, for example the Advanced Research Projects Agency-Energy (ARPA-E), the US has not passed any major energy and environmental legislation over the past year, in part because of concerns about the effects of these types of regulations on the economic recovery.

[4] http://www.noaa.gov

Assessment of the national policies/measures

The US has long been a desirable location for international education and research work in part because of the quality of its universities. In addition, the US has a solid research infrastructure with access increased in recent years through investments small scale research infrastructure. Concerns about the level of funding for university research have been raised in light of state and federal budget cuts. Although large scale technology transfer policies are not widespread in the US system, the innovativeness of the private sector and success of measures such as the SBIR programme are indicative of a system in which the private sector and research institutions have collaborative engagement. Budget constraints result in the US investing less over the past year in international exchanges of researchers. The longstanding Fulbright Hayes programme, which received budget increases after the 9/11 terrorist attacks, was cut substantially in fiscal year 2012 to €184m, $230m from €190m, $238m in 2011; the programme received a slight 0.6% increase in the 2013 continuing resolution budget. Although these budget signal elimination of dissertation and research abroad awards, the US still maintains numerous linkages with EU and non-EU countries through multiple mechanisms including 54 umbrella science and technology agreements.

	Objectives	Main national policy changes over the last year	Assessment of strengths and weaknesses
1	Labour market for researchers	The fiscal year 2013 budget for the Fulbright Hayes programme was 0.6% higher than the previous fiscal year.	The US has long been a desired location for international education and work. However, national security issues and concerns about the availability of jobs for the domestic labour force have at times limited the openness of the US market.
2	Research infrastructures	Infrastructure for assessing large scale data has received renewed attention through a series of multi-agency solicitations termed “Big Data,” which seek to receive more knowledge from large scale datasets.	Small scale research infrastructure at universities and other research institutions has received support but large scale infrastructure remains an issue (National Academies 2006)
3	Strengthening research institutions	The President’s Council of Advisors on Science and Technology issued a report, “Transformation and Opportunity: The Future of the U.S. Research Enterprise” on November 2012 which highlights challenges faced by university, government, and private sector institutions and calls for several specific recommendations including setting R&D expenditures at 3% of GDP, eliminating superfluous regulations for research-intensive businesses and universities, and developing federal budgets for future year funding of R&D (PCAST 2012).	The US higher education system is large and diverse. It research universities are often at the top of global rankings. (Times 2012) Declines in the US world share of articles continue to be monitored (National Science Board 2012) and concerns about funding streams available for university research (National Research Council 2012).
4	Knowledge transfer	The Small Business Innovation Research (SBIR) programme has new amendments to its regulations concerning ownership, control and	The US has a strong and innovative private sector with great capacity to absorb and develop innovations. However,

		affiliation, which went into effect in January 28, 2013. The new amendments allow small firms that are majority owned by multiple venture capital companies to participate in the programme.	outside of SBIR, there are few programmes with substantial scale to promote widespread public-private cooperation and knowledge transfer. Private sector firms are concerned about the administrative costs associated with these kinds of relationships.
5	International R&D cooperation with EU member states	Networks of Diasporas in Engineering and Science (NODES) was established in 2012 to build greater connections with foreign scientists in the US.[5]	The US has 15 umbrella science and technology agreements with EU member states and one with the EU. There is no national strategy for these types of R&D cooperation.
6	International R&D cooperation with non-EU countries	(Refer to number 5 above.)	The US has 38 umbrella science and technology agreements with non-EU countries. There is no national strategy for these types of R&D cooperation.

[5] http://www.state.gov/r/pa/prs/ps/2012/07/195525.htm

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7 LIST OF ABBREVIATIONS

ARRA	American Recovery and Reinvestment Act
ARPA-E	Advanced Research Projects Agency - Energy
BERD	Business Expenditures for Research and Development
CERN	European Organisation for Nuclear Research
ERA	European Research Area
COST	European Cooperation in Science and Technology
DARPA	Defence Advanced Research Projects Agency
ERA-NET	European Research Area Network
ERC	Engineering Research Centres
ERP Fund	European Recovery Programme Fund
ESA	European Space Agency
ESFRI	European Strategy Forum on Research Infrastructures
FP	European Framework Programme for Research and Technology Development
EU	European Union
EU-27	European Union including 27 Member States
FDI	Foreign Direct Investments
FP	Framework Programme
FP7	7th Framework Programme
GBAORD	Government Budget Appropriations or Outlays on R&D
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GOCO	Government Owned Contractor Operated
GOVERD	Government Intramural Expenditure on R&D
GUF	General University Funds
HEI	Higher education institutions
HERD	Higher Education Expenditure on R&D
HES	Higher education sector
IP	Intellectual Property
PRO	Public Research Organisations
OECD	Organisation for Economic Co-operation and Development
OMB	Office of Management and Budget
M&O	Management & Operations
MEP	Manufacturing Extension Partnership
NIST	US National Institute of Standards and Technology
NIH	National Institutes of Health
NSF	National Science Foundation
PART	Program Assessment Rating Tool
R&D	Research and development
R&D&I	Research and development and Innovation
RI	Research Infrastructures
RTDI	Research Technological Development and Innovation

SBIR	Small Business Innovation Research
SF	Structural Funds
SME	Small and Medium Sized Enterprise
S&T	Science and technology
TIP	Technology Innovation Programme (TIP)
VC	Venture Capital