ERAWATCH COUNTRY REPORTS 2010: 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 €10.4 trillion ($14.6 trillion) or €33,600 on a per capita basis, ($47,000). Its population is the third largest in the world and the largest among countries in North America, comprising nearly 90% 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 €270.7b ($398.1b) in 2008. GERD (in US dollars) increased by more than 14% from 2006 to 2008, a rate higher than that of the larger economy (i.e., GDP), which grew by more than 7% during the same time period. The private sector funds nearly two-thirds of all R&D and performs more than 70% all R&D. Government funding accounts for more than one-fourth of R&D in the US, but the government-funded public research organizations perform only 4% of all R&D, with higher educational institutions performing the lion's share of the remainder. Youtie (2011) The economic crisis prompted one-time expenditures through the American Recovery and Reinvestment Act (ARRA) of 2009, including €15.0 billion ($19 billion) for increased public R&D. However, rising budget deficits have led to a levelling of government funded R&D expenditures in subsequent years.

At the national level, the US system has long had a direct policy emphasis on research investments but fewer explicit initiatives for promoting private investments in R&D. The current administration has initiated several cross-agency programmes over the past two years to promote greater linkage between research and innovation policy within regional innovation clusters. Outcomes of these types of programmes are limited by ongoing effects of the economic downturn. The economic downturn also has 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. The budget compromise reached in April 2011 represented €27b ($38b) in reductions, which is important to maintaining fiscal stability. As a result of these reductions, there is limited flexibility to make substantial federal investments in policy areas such as 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 in some observers who give notice of increased research and innovation competition in Europe and Asia and a lack of capacity for a compelling US response. (National Academies 2010)

Knowledge Triangle

US support for research policy reflects the general favourable view of role of the federal government in making science investments. The energy area is a particular priority of the current administration; one of the strategic measures in this area for creating energy breakthroughs is Advanced Research Projects Agency-Energy (ARPA-E). Innovation policy has seen new activity in the current administration, particularly in multi-agency federal programmes to support "regional innovation clusters" or geographically-bounded concentrations of businesses in technology-intensive industries, as a mechanism to stimulate employment. Education quality is an ongoing concern in the US, although it is primarily the purview of state governments, with the federal government having a somewhat limited role. 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 increased investment and programmes to promote energy research, such as the creation of and funding for ARPA-E.	Support for basic research is more broad-based whereas there is less support for applied research in the US budget. (AAAS 2011) Research policy budgets are less predictable in the current budget crisis. US research policy is based on competition and peer review and is coordinated through the Office of Science and Technology Policy
Innovation policy	There have been several multi-agency programmes that follow a "regional innovation cluster" model, including Energy Efficient Building Systems Regional Innovation Cluster Initiative (E-RIC), and I6 Challenge. In addition, the federal government has authorising legislation to hold prize competitions to address grand challenges.	The US generally has a favourable environment for innovation. (World Economic Forum 2011) However, gaps still remain, for example, in patent reform, which continues to be debated but has not been signed into legislation in recent years. US innovation policy is less coordinated than research policy is.
Education policy	The recent US budget compromise on the fiscal year 2011 includes substantial education cuts including in global exchange programmes, international education, and foreign language study.	Tertiary education is a strength in the US system, while primary and secondary education often compares less favourably with international counterparts. State budget shortfalls mean fewer resources are available to primary and secondary education as well as public universities and colleges.
Other policies	The US Environmental Protection Agency is issuing regulations	The US has some strong research programmes in the energy and environmental area. However, the US has

	under the 1977 Clean Air Act to address greenhouse gas emissions aspects of new facility permitting for large scale utilities and oil refinery projects. (Environmental Protection Agency 2011)	not passed any substantial energy and environmental regulation over the past year, in part because of concerns about the effects of these types of regulations on the economic recovery.

European Research Area

Research: US policies to increase public support for research have received general backing in the re-authorisation in 2011 of the America COMPETES Act. Research support policies are undergirded by strengths in and continued emphasis on quality (via the US peer–review system), highly-ranked US universities, and relatively good access to world-class research infrastructure. In addition, mobilising research to address societal challenges, particularly in the energy area, have become more important in the US system under the current administration. Programmes to support societal response to scientific research are evidenced in small but important initiatives that are part of the National Nanotechnology Initiative. Research capacity questions concerning the distribution of federal R&D investments are addressed in a few programmes such as EPSCoR, but they are very small. Questions about human capital capacities are raised from time-to-time in debates about visa limits and processes.

Commercialisation: The US provides a good environment for research-based commercialisation. Private investment through the SBIR and R&D tax credits face a challenge, however, in that these initiatives have to be regularly renewed. Programmes that appear to direct industry activity attract less support at the federal level, which limits initiatives to promote public-private transfer and knowledge circulation, albeit such initiatives operate in a slightly more favourable climate in the current administration. There is less emphasis in the US system on transitioning to a knowledge-intensive economy and greater concern about re-balancing the economy to stimulate manufacturing jobs.

Coordination: Coordination – including integration of research and joint design of policies – is an ongoing challenge in the decentralised US system. This issue has seen renewed attention in new multi-agency regional innovation cluster programmes as well as existing support in the cross-agency National Nanotechnology Initiative. Coordination between the US and the international community on research issues continues through multiple bilateral and multi-lateral treaties.

Assessment of the national policies/measures which correspond to ERA objectives[1]

[1] Of course non-ERA countries do not strive to achieve ERA objectives. This part of the report is simply to allow a comparison with the activities of ERA countries on these issues

	ERA objectives	Relevant national policy actions	Assessment of strengths and weaknesses
1	Ensure an adequate supply of human resources for research and an open, attractive and competitive labour market for male and female researchers	Programmes to encourage international exchange, such as the Fulbright Program (Public Law 584) support, and visa regulations and relevant.	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 has at times limited the openness of the US market.
2	Increase public support for research	The America COMPETES Act of 2007 (Public Law 110–69.) which calls for a doubling of the research budgets of three federal agencies and institutes ARPA-E to enable breakthrough energy-related research.	This act was re-authorised in 2011. However, fiscal challenges in the US budget have limited the ability to provide envisioned levels of public support for research.
3	Increase coordination and integration of research funding	The National Nanotechnology Initiative coordinates public investments in nanotechnology across 26 federal agencies.	The decentralised, bottom-up nature of the US policy system, which offers strengths in accessibility, can create difficulties in ensuring coordination and integration.
4	Enhance research capacity	Experimental Program to Stimulate Competitive Research (EPSCoR) programme.	Programs such as EPSCoR provide planning infrastructure and seed research funding which is needed for development of research capacity. At the same time, many of these programmes are rather small in size relative to the total amounts of research funding available.
5	Develop world-class research infrastructures (including e-infrastructures) and ensure access to them	NSF's Major Research Instrumentation Program, which includes the CISE Computing Research Infrastructure.	The US has good research instrumentation funding programmes for small scale instruments but coordination issues and the availability of funding for large scale instruments and operation and maintenance remain at issue. (National Academies 2006)
6	Strengthen research institutions, including notably universities	Aside from programmes such as EPSCoR (which is targeted to US states rather than research institutions) there are no national policies directed at universities.	The US higher education system is large and diverse. It research universities are often at the top of global rankings. (Times 2010) Declines in the US world share of articles continue to be monitored. (National Science Board 2010)
7	Improve framework conditions for private investment in R&D	Small Business Innovation Research Programme. Research and Experimentation Tax Credit	The US has a relatively strong and diverse environment for private R&D investment. However, the effect of the economic downturn on the availability of venture capital and the lack of permanence of the US

	ERA objectives	Relevant national policy actions	Assessment of strengths and weaknesses
			Research and Experimentation Tax Credit offer opportunities for enhancement.
8	Promote public-private cooperation and knowledge transfer	Technology Innovation Program The University and Small Business Patent Procedure Act (Bayh–Dole Act), Public Law 96-517	The US has a strong and innovative private sector with great capacity to absorb and develop innovations. However, 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.
9	Enhance knowledge circulation	Manufacturing Extension Partnership (MEP)	The MEP programme transfers knowledge to small and medium-sized manufacturers to enhance their competitiveness. The strength of programmes such as these is to provide supply-side knowledge but the US has relatively few demand-side initiatives (e.g., no innovation voucher programmes)
10	Strengthen international cooperation in science and technology	Agreement for scientific and technological cooperation between the European Community and the Government of the United States of America	Establishes a general structure for research and technological collaboration in scientific areas. Other types of agreements are required for scientific cooperation with individual European countries or, in some cases, particular research fields.
11	Jointly design and coordinate policies across policy levels and policy areas, notably within the knowledge triangle	Regional innovation cluster programmes (e.g., Energy Efficient Building Systems Regional Innovation Cluster Initiative, E-RIC, I6)	Although the openness and decentralisation of the US system can be a strength in terms of enabling flexible response to change, it can also pose challenges in terms of joint design and coordination of policies across policy levels.
12	Develop and sustain excellence and overall quality of research	Peer review process	Peer review is the most commonly used method for maintaining research quality, although it has been criticised for sometimes yielding conservative outcomes. (Piore 2011)
13	Promote structural change and specialisation towards a more knowledge - intensive economy	EDA I6 Challenge	Structural change and knowledge-intensive economy promotion are more common at the state than the national level. However, recent national policies concerning regional innovation clusters, such as the EDA I6 Challenge, promote development of bioscience and green

	ERA objectives	Relevant national policy actions	Assessment of strengths and weaknesses
			economies.
14	Mobilise research to address major societal challenges and contribute to sustainable development	The America COMPETES Reauthorization Act of 2010, Public Law No: 111-358, section 105.	Federal agencies are given the authority to award prizes to encourage innovation and address major challenges within the agencies' missions. As this act was just signed into law early in 2011, the processes and outcomes from these types of prizes are untested.
15	Build mutual trust between science and society and strengthen scientific evidence for policy making	Societal Nanoscale Science and Engineering Centers	The National Nanotechnology Initiative has made explicit investments in societal programmes to provide evidence for policy making and foster communication with the public at-large. The National Nanotechnology Initiative budget for these types of programmes has seen substantially greater reductions for societal programmes than for other R&D programmes.

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1 Introduction

The main objective of the ERAWATCH International Analytical Country Reports 2010 is to characterise and assess the evolution of the national policy mixes for the non-EU countries in the perspective of the Lisbon goals and of the 2020 post-Lisbon Strategy, even though they do not pursue these policies themselves. The assessment will focus on the national R&D investments targets, the efficiency and effectiveness of national policies and investments into R&D, the articulation between research, education and innovation. In doing this, the 15 objectives of the ERA 2020 are articulated.

Given the latest developments, the 2010 Country Report has a stronger focus on the link between research and innovation, reflecting the increased focus of innovation in the policy agenda. The report is not aimed to cover innovation per se, but rather the 'interlinkage' between research and innovation, in terms of their wider governance and policy mix.

2 Performance of the national research and innovation system and assessment of recent policy changes

The aim of this chapter is to assess the performance of the national research system, the 'interlinkages' between research and innovation systems, in terms of their wider governance and policy as well as the most recent changes that have occurred in national policy mixes in the perspective of the Lisbon goals. Each section identifies the main societal challenges addressed by the national research and innovation system and assesses the policy measures that address these challenges. The relevant objectives derived from ERA 2020 Vision are articulated in the assessment for comparison reasons.

2.1 Structure of the national research and innovation system and its governance

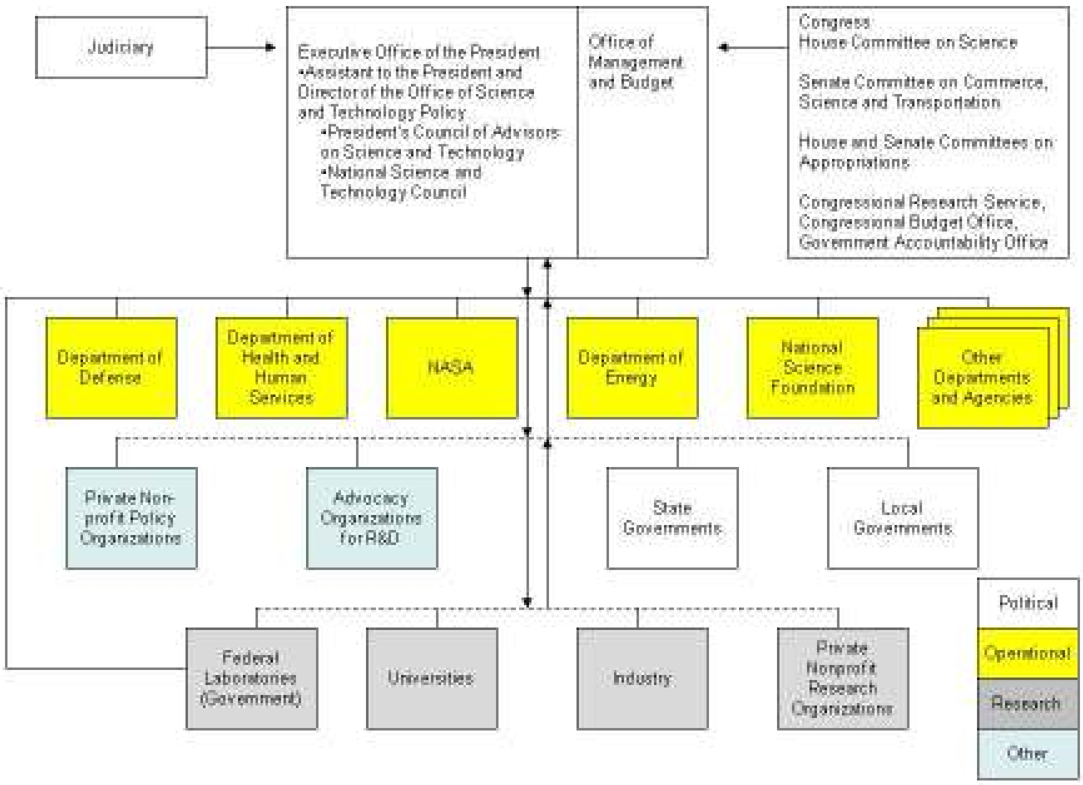
This section gives the main characteristics of the structure of the national research and innovation systems, in terms of their wider governance.

The United States of America (US) has the largest economy in the world with GDP (purchasing power parity) of around €10.4 trillion ($14.6 trillion) or €33,600 on a per capita basis, ($47,000). (US Bureau of Economic Analysis 2011) At more than 311 million, the US represents the third largest in the world and the largest among countries in North America, comprising nearly 90% of all North Americans. The US has a large R&D sector – representing €270,7b ($398.1b) in 2008. GERD (in US dollars) increased by more than 14% from 2006 to 2008, a rate higher than that of the larger economy, which grew by more than 7% in current dollars during the same time period. 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.

Main actors and institutions in research governance

The US research system is large and decentralised. Policy is shaped in 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 Defense 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; however 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 (2011).

The US has traditionally been among the leaders in its policy processes. Several US research agencies – such as the National Science Foundation and the Defense Advanced Research Projects Agency (DARPA) have been emulated within and outside of the US. In addition, various innovation policies – such as the Small Business Innovation Research (SBIR) programme, which promotes government R&D funding opportunities for small and medium-sized companies, and the Bayh-Dole Act which fosters intellectual property protection and licensing of publicly-funded research — have served as models for adoption by other countries. In addition, US institutional mechanisms for innovation are among the most prominent in the world. For example, the US higher educational system, which is comprised of large and varied public universities managed by state governments and private universities structured as private non-profits, features many top universities that have extensively studied models and US research universities frequently are situated at the top of independent worldwide rankings. (The Economist 2005) On the other hand, pluralism and decentralisation, which are hallmarks of the US innovation system, present coordination concerns among policy actors even as the system also offers strengths in variety and approachability.

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 22% of US R&D. The next largest state, Massachusetts, performs 7% of US R&D. Once the size of the state is accounted for – by dividing R&D by GDP for example – New Mexico (which is the location of two national research laboratories) receives the highest rank, followed by Massachusetts. 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 73% all R&D. Government funding accounts for more than one-fourth of R&D in the US, but the government (via public research organisations) performs only 4% of all R&D. Higher educational institutions performing 13% of the R&D.

2.2 Resource mobilisation

This section will assess the progress towards national R&D targets, with particular focus on private R&D and of recent policy measures and governance changes and the status of key existing measures, taking into account recent government budget data. The assessment will include also the human resources for R&D. Main *assessment criteria are the degree of compliance with national targets and the coherence of policy objectives and policy instruments.*

2.2.1 Resource provision for research activities

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. (Executive Office of the President 2009) Gross R&D expenditures as a percentage of GDP rose from 2.5% in 2005 to nearly 2.8% by 2008. 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 budget (Sargent 2010) and budget cuts, albeit not as severe as other agencies experienced. For example, the 2011 continuing resolution budget for the National Science Foundation was 1% less than 2010 levels and the Department of Energy's Office of Science budget was .4% less; by comparison, expenditures in the overall 2011 continuing resolution budget were 4% lower than 2010 levels.

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 Program Assessment Rating Tool (PART). This tool highlights strengths and weaknesses of federal programs, 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 Defense, 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 – €321m ($450m) compared to the overall R&D budget (roughly €100b). 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 Program, which promotes R&D in company-university partnerships. This programme amounts to 0.3-0.5% of the budgets of agencies with €0.7b ($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 the negotiations around the continuing resolution for fiscal year 2011. As indicated, these negotiations resulted in an overall 4% cut in federal spending. Basic research budget reductions tended to be below these levels, whereas applied research budgets were more apt to see higher cuts, for example Energy Efficiency and Renewable Energy (EERE) programme received an 18% cut.

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 3% of its budget to addressing education and societal dimensions.

Grand challenges do not explicitly guide resource allocations in the US. There are no particular targets for formally defined grand challenges. At the same time, the current administration has steered an increasing share of the R&D budget toward energy research. R&D expenditures in the Department of Energy rose by 8% from 2009 to 2010, although they have since declined in the 2011 budget negotiations.

However, there are examples of the use of grand challenges in research policy in the US. The energy area provides an example of periods of major activity and inactivity in a societal challenge with the potential to promote structural economic change. During the energy crisis of the 1970s, the Carter administration made an investment in R&D for solar energy and other renewables. Subsequent decades saw less activity in the energy area. In the 2000s, the Bush administration highlighted hydrogen and fuel cell R&D in the €.9b ($1.2b) Hydrogen Fuel Initiative. The Obama administration made energy programmes a major component of its economic stimulus policy. The ARRA authorised stimulus spending of about 13%, or €78.2b ($101.9b), of the stimulus package is devoted to technology, energy and R&D spending. This includes €35.0 billion ($45.1b) in renewable-energy incentives and €8.4b ($11.0b) to develop smart electricity grids. In addition, the stimulus legislation allocated €286m ($400m) to fund ARPA-E for long-range breakthrough energy research and €129m ($180m) in subsequent annual appropriations. Estimates associated with the stimulus legislation, especially elements fostering energy investments, suggested that two-to-five million “green collar jobs” could be created from these initiatives. These policies represent the ability of the federal government to be responsive in a major way to a societal challenge and the promotion of structural change. On the other hand, the market-driven nature of energy commercialisation has the potential to be limited by the various agencies, commissions, oversight committees, and other stakeholders involved in the domain.

2.2.2 Evolution of national policy mix geared towards the national R&D investment targets

Business R&D expenditures have grown by 17% from 2005 to 2008 compared to 7% for GDP. This growth rate is slightly higher than the European average of 14%. 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%. 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-authorised periodically to address its expiration), and at the state level through various state R&D tax credits.

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 Program (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.

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. By industrial policy, we mean 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 associated with the €269b ($350b) spent 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 Defense Acquisitions University – help with information sharing and training for public procurement workers. The Defense 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 – with the exception of the SBIR programme – public procurement does have that effect. This is particularly the case with defence procurements. Defence procurement of transistors and aircraft have 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).

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.

2.2.3 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 comparable. (Youtie 2011) 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.

The latest NSF Science and Engineering Indicators data suggests enrolment in science and engineering programmes has increased at the undergraduate and graduate levels among US citizens and permanent residents. In addition, foreign-born students at the graduate levels have increased in the last two years after several years of declines. In addition, post-doctorate positions have substantially increased, primarily as a result of foreign students. The unemployment rate has been higher among computer science and life science fields and lowest among graduates in engineering fields. (National Science Board 2010) 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 €15.4 million ($20 million) to nine universities for entrepreneurship curriculum development, research into entrepreneurship, facilities construction, technology tools, mentorship networking, and expansion of activities into liberal arts programs. In addition, technical fields are increasingly incorporating "soft" skills such as team-based project work, communication and presentation opportunities, and creativity and problem-solving skills. These are emphasised 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.

2.3 *Knowledge demand*

This section focuses on structure of knowledge demand drivers and analysis of recent policy changes

Demand for research-based knowledge is proxied 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 (21%), chemicals (19%), and transportation equipment 15%. 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 sectoral allocation of value added. Service producing industries account for 78%

of US value-added. The finance/insurance/real estate sector accounts for 24% of the US economic but only 0.5% of R&D expenditures. Professional business services is a relatively balanced sector in terms of its demand for R&D and sectoral allocation of value-added. Professional business services comprises 14% of total R&D business expenditures. It also accounts for 14% of private sector value-added. (National Science Foundation 2011a, Bureau of Economic Analysis 2011). Thus, the relationship between knowledge demand and sectoral 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.

2.4 *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.

2.4.1 Quality and excellence of knowledge production

The US has the largest and most influential national research system. This system is supported by €103.4b ($144.7b) in government funding for R&D in fiscal year 2011. There are 96 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 some 40 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 28% in 2007, 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 50% from 2003 to 2007. The number of patents from US universities has also generally risen, with the exception of 2008. (National Science Board 2010)

2.4.2 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 about the use of "earmarks," which designate moneys in appropriations bills for certain research projects in an elected official's jurisdiction. The concern is that these earmarks by-pass the formal research quality system of peer review. However, 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.

2.5 Knowledge circulation

This section provides an assessment of the actions at national level aiming to allow an efficient flow of knowledge between different R&D actors and across borders.

2.5.1 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 Center (ERC) program 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 €1.4m ($2m) a year in federal funding and there are 13 ERCs as of April 2011 organised around three knowledge clusters: 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 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 €71.4m ($100m) with moderate increases during the Obama administration. 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)

2.5.2 Cross-border knowledge circulation

Research collaboration between national and foreign research organisations is strong and support in diverse ways. Many competitive research solicitations allow for international organisations to act as subcontractors. National funding procedures are adjusted in the contracts in that they do not allow for indirect cost recovery by the foreign institutions. In addition, international collaborative research is monitored to gauge changes over time. (National Science Board 2010) The US also has led and or participated in several large scale research projects including the European Organisation for Nuclear Research (CERN) as a special observer and the

International Space Station as a leader and founder. Various national measures exist to support cross-border cooperation. The Fulbright Program was originally established after World War II to advance US-European research and teaching relationships through support for international exchanges. Many of the research-intensive federal agencies have international offices, for example the NSF's Office of International Science and Engineering which supports international travel and workshops pertaining to science and engineering.

2.5.3 Main societal challenges

US science agreements with the Europe Union and European member states focus on specific research fields, including fields that relate to grand challenges. The most common areas of cooperation within these agreements include agriculture, energy, environment and climate change, health, and basic research. These areas are among the high priority areas of the US Department of State for international collaboration.

2.6 *Overall assessment*

The US has a large research system, although the economic downturn and budget deficit has resulted in limits to public funding of this research system. US companies are sophisticated in their demand for R&D. However, the hesitancy to link research and commercialisation in policy creates the potential for gaps in coordination between the two systems. The US is an important producer of knowledge but concerns about the rise of Asia in terms of production of publications and patents are monitored. In terms of knowledge-circulation, the US has longstanding policies to promote technology transfer from universities and government laboratories to industry, but the US does not have a strong system of formal demand-led innovation policies.

Table 1: Summary of main policy related opportunities and risks

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	The US is a large country with many resources available for research activities. In addition, it has a large decentralised policy system which offers opportunities for access at various levels of government.	The economic downturn and concerns about the budget deficit have resulted in limits on research resources (which are considered part of the "discretionary" US budget and therefore draws attention in budget reduction decisions.)
Knowledge demand	The US has a large, sophisticated, private sector including multi-national corporations, small high technology start-up firms, and mature existing industries.	The lack of coordination and hesitancy to link research and the innovation process in private industry has the potential to limit knowledge demand.
Knowledge production	The US is a major producer of research, much of which is among the most influential in the world. Its universities are often at the top of international rankings.	The US monitors and raises concerns about the rapid growth of research in Asian institutions and subsequent falling of relative share of US authored publications and US assigned patents.
Knowledge circulation	The US system offers multiple avenues for the transfer of knowledge between universities and government laboratories and private industry. In addition, there	The US is relatively weak on policy measures to promote demand-driven knowledge circulation. There is no formal innovation voucher

	are several "boundary spanning" policies and organisations to promote knowledge circulation.	system in the US.

The US has a very large and private-sector oriented R&D system, but this system increasingly focuses on development rather than on long-range research, which may affect its future competitiveness. This situation, coupled with the declining ability of the federal government to increase research investments, due to the federal budget crisis, means that there will be less money available for basic research in the US. In the energy area, the US faces demand-side and marketing coordination challenges to commercialising energy research even though the current administration has made this area a priority. The large innovation finance system in the US is limited by the financial crisis and the lesser availability of capital, which further hampers commercialisation efforts.

Table 2: Main barriers to R&D investments and respective policy opportunities and risks

Barriers to R&D investment	Opportunities and Risks generated by the policy mix
Emphasis on development in private sector R&D	The US has a large private sector R&D system, but the emphasis on development poses a risk for long-run innovation.
Slow commercialisation of energy research	There has been a rise in federal energy-related investment. Still this area has a long time horizon and requires a level market coordination and demand that is not as present in the US than in other countries.
Innovation finance	The US innovation finance system (e.g., venture capital) is among the largest in the world. However, the credit crisis in 2008 and 2009 has had a weakening effect on the US financial system.
Declines in federal R&D resources	The US has a robust set of resources to fund R&D performance. However the current budget deficit is likely to result in continued cuts in federal R&D investments.

3 National policies which correspond to ERA objectives

3.1 Labour market for researchers

3.1.1 Stocks and mobility flows of researchers

The US has about 5.5m employees in science and engineering occupations or 1.8% of the total US population. Roughly 60% of these science and engineering workers perform R&D as a major work activity. Unemployment rates for science and engineering employees from 1983 to 2008 ranged from 1.3% to 4% compared with the 4% to 9% unemployment rate for all workers. In 2008, these figures were just below 4% for science and engineering employees compared to just below 6% for all workers. At the same time, the economic downturn has been observed to affect science and engineering as unemployment rates in April 2009 rose to 4.3% for these employees. This rate was reported to be at the highest levels in 25 years. (National Science Board 2010)

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 2006. 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. More than 20% of US doctoral students are from outside the country. However, the share of foreign postdoctoral students is much higher in that 57% of US postdoctoral students are foreign.

The US also has a comparatively small number of students that study outside the country. There are 49,000 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 lower salaries as well as to have access to larger talent pools and facilitate market entry. There are no national salary specifications for R&D employees in universities and private non-profit research institutes, 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 Defense 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. 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 is administering 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 Meeting the social security and supplementary pension needs of mobile researchers

Social security is not affected by researchers' mobility. However, university or public research institutions usually have a certain number of years of vesting required before the research is qualified to receive a pension. If the researcher leaves during this vesting period, his or her pension is forfeited. Once the researcher is vested, the pension will be received by the researcher upon retirement. Defined contribution plans such as 401ks may be "rolled over" or transferred to a new administrator if the employee takes a job with another institution.

3.1.5 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 degree is more flexible, which in the past did not always provide 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, 2011).

3.2 *Research infrastructures*

Research infrastructures (RIs) are a key instrument in the creation of new knowledge and, by implication, innovation, in bringing together a wide diversity of stakeholders, helping to create a new research environment in which researchers have shared access to scientific facilities.

3.2.1 National Research Infrastructures roadmap

The US does not have a national research infrastructure roadmap. NSF estimates that about €1.4b ($1.9b) was spent on research infrastructures at universities. Funding from the federal government supported 57% or €.77b ($1.1b) 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 1% from fiscal years 2007 to 2008 but declined by 10% in constant dollars from 2004 levels. (National Science Board 2010)

At the government research laboratory level, the US Department of Energy (DOE) operates the largest system of national laboratories. DOE laboratories account for 20 of the 40 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. The DOE laboratories had a €6.6m ($918m) facilities budget in fiscal year 2011. This DOE laboratory research budget represents a 2.1% decline following recent budget negotiations. (AAAS 2011)

3.3 *Strengthening research institutions*

This section gives an overview of the main features of the national higher education system, assessing its research performance, the level of academic autonomy achieved so far, dominant governing and funding models.

3.3.1 Quality of National Higher Education System

The US has 4300 tertiary-level institutions. Nearly 19 million students, which equates to 6% of the US population, enrolled in higher educational institutions in 2007. 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 2007, more than 18.5 million students were enrolled in higher education. Forty-three percent of graduates are male and 57% are female. In 2008-9, 3.2 million students received degrees, 2% of which were doctoral degrees. Males accounted for 41% of these degrees. The distribution of degrees across fields indicates that business accounted for 21% of bachelor's degrees, followed by humanities at 18% 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. One-in five doctoral degrees was in the natural sciences. (US Department of Education 2010)

Thirty-seven percent of all doctoral degrees were granted to non-residents of the US, but only 3% of all bachelor's degrees were granted to non-residents of the US.

Higher educational institutions perform about 13% of US R&D. Academic R&D grew by nearly 6% from 2008 to 2009 and 20% from 2005 to 2009. Private sector support accounts for nearly 6% of all academic R&D funding sources in the US, with the federal government representing the largest funder of university research (59%).

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. Ninety-six 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 28% of Science and Social Science Citation Index papers, the largest after the European Union, although twelve-year growth rates are much lower for the US (at 0.7%) than Asia in general (at 9%) and China in particular at (16.5%). Co-authorship with researchers in other countries is on the rise in the US, representing 30% of all US papers in 2008, up from 20% in 1998. During the same time period, the European Union also increased international collaboration rates (from 21% to 29%), while China's international collaboration rate stayed about the same at approximately 25%. (National Science Board 2010) In addition, the US has the largest number of foreign students. In the Shanghai Academic Ranking of World Universities (2011), eight of the top 10 and more than half of the top 100 are American universities.

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 2009. (National Science Foundation, 2011b) 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

This section will assess the national policy efforts aimed to promote the national and trans-national public-private knowledge transfer.

3.4.1 Intellectual Property Policies

University's and public research organisation's 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

Spin-offs

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 Small Business Innovation Research (SBIR) grants, entrepreneurship education, and networking events such as venture forums. (Tornatzky et al 2002)

Involvement of private sectors 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.

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.

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 *Cooperation, coordination and opening up national research programmes with the EU*

This section assesses the effectiveness of national policy efforts aiming to improve the coordination of policies and policy instruments across the EU.

3.5.1 National participation in intergovernmental organisations and schemes

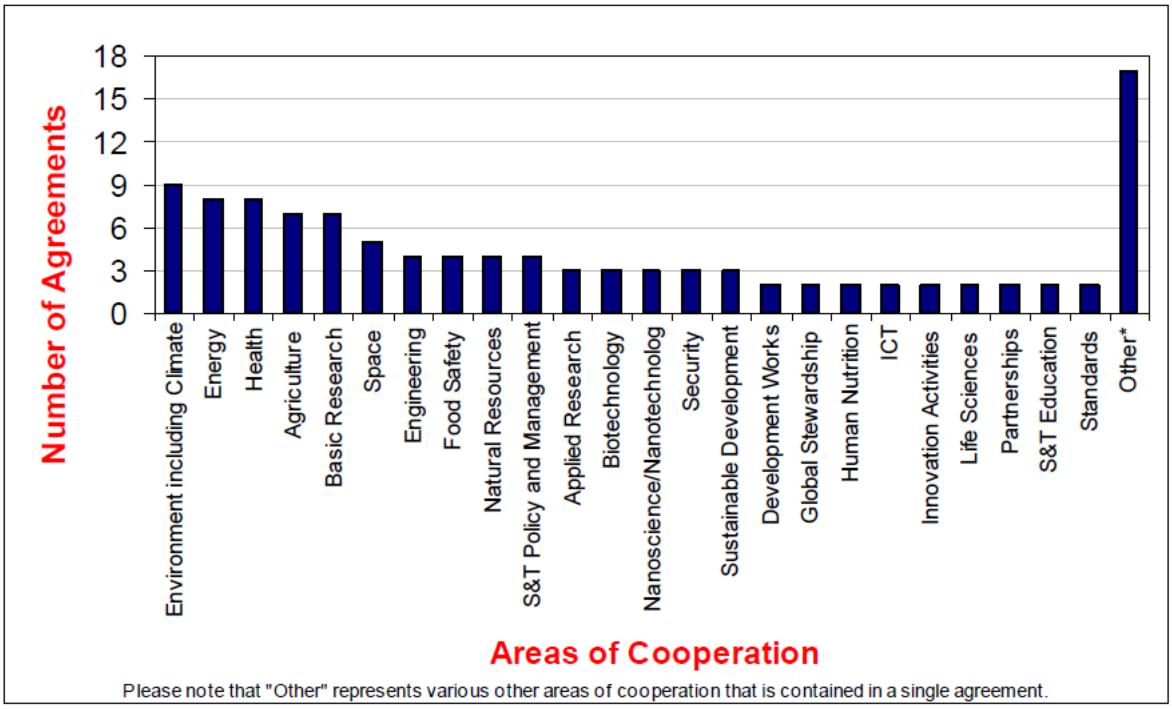
From January 2007 to December 2009, 281 FP7 grants involving 119 US organisations were awarded. These grants represented a total of €389 million, with €13 million going to the US recipients. Grant awards to the US were largest in the health field, which comprised one-third of FP7 funding to US organisations in 2008 and nearly half of FP7 funding in 2009. ICT accounted for 28% of FP7 funding in 2007 and 16% in 2008. In 2008, grant awards associated with the Knowledge Based Bio-Economy theme comprised 16% of all FP7 funding to US organisations. In 2009, grant awards associated with energy were more prominent, accounting for 23% of FP7 funding that year. (Bilat-USA 2011)

Although the US does not have a national strategy for participation in inter-governmental research infrastructures, it does participate in several of these large-scale research programmes. 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 has been a leading and founding partner, through the National Aeronautics and Space Administration, in the International Space Station since 1998 so that a platform for space research would exist. 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, 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.

3.5.2 Bi- and multilateral RDI agreements with EU countries

The US has Umbrella Science and Technology Agreements with 37 countries, including the European Union and 16 European countries and associated members:

Bulgaria, Italy, Croatia, Macedonia, Denmark, Poland, Romania, Finland, Slovakia, Hungary, Slovenia, Germany, Spain, Greece, Sweden, Switzerland. These agreements provide frameworks for science and technology cooperation, intellectual property protection, research access, and related topics. Thirteen reference explicit areas of cooperation as shown in the figure below. The most common area is environmental (in nine of the agreements), followed by energy and health (in eight agreements), and agriculture and basic research (in seven of the agreements).



Source: Pals S., Wang, T. (2010). US Science and Technology Cooperation Agreements with Europe: Survey & Analysis. Washington DC: Link2US, p. 8.

3.5.3 Other instruments of cooperation and coordination between national R&D programmes

Individual European governments have science and technology staff functions and offices in their Embassies and Consulates in the United States. A particularly active unit is the Austrian Office of Science and Technology in Washington DC which engages in information dissemination, policy advice, and supports new R&D collaborations by serving as the coordinator of the BILAT-USA consortium (Source: http://www.euussciencetechnology.eu/). BILAT-USA maintains an inventory of projects to provide for their visibility. These include several Era-Net projects in which, although the US does not formally participate in these projects, information about 46 Era-Net projects is presented on the BILAT-USA web site, including: ERA-ENVHEALTH, ICT-AGRI, iMERA-PLUS, MATER+, NANOSCI-EPLUS, POLYMAP, SMSRTGRIDS ERA-NET, WOODWISDOM-NET2.

The US also participates in several Networks of Excellence (NoEs). These include: ACOBAR, NANORETOX, SOILTREC, SYNER-G, Transatlantic TUmour MOdel Repositories (TUMOR).

US participation in public-private partnerships often takes place through European subsidiaries of US headquartered multi-nationals. For example, Motorola participated in the European Commission's European Directive for Mobile Communication (E112) e-Call initiative in 2005. (Tsai 2005)

The dominance policy approaches supporting the cooperation and coordination between national R&D programmes consist of several mechanisms. In addition to bi- and multi-lateral agreements, the US and EU operate thematic working groups and task forces that provide a framework for European and US cooperation and dialog in selected areas. As of 2010, there are three Joint US-EU thematic task forces: the US-EU Energy Council, EU-US Task Force on Biotechnology Research, and Task force to combat antimicrobial resistance. There are also summits, conferences, and symposiums on different topical areas to foster cooperation and coordination. Several technical papers have been produced by BILAT-USA and Link2USA to summarise shared activity and facilitate cooperation. (Bilat-USA 2011)

3.5.4 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.

3.6 *International science and technology cooperation*

3.6.1 International cooperation (beyond EU)

The US State Department indicates several areas of collaboration in international science and technology cooperation. These areas correspond to grand 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 contained in all of these agreements (US Department of State, Science & Technology Cooperation, http://www.state.gov).

The US government has 37 umbrella science and technology agreements. These agreements include third countries such as Algeria, Argentina, Armenia, Australia, Bangladesh, Brazil, Chile, China, Egypt, India, Japan, Korea, Mexico, Mongolia, Morocco, New Zealand, Pakistan, Philippines, Russia, South Africa, Tunisia, and Vietnam.

The US is involved in initiatives that engage European and third countries. For example, the Global Partnership Initiative brings together public-private partnerships from countries around the world to foster effective economic outcomes. The Major Economies Forum on Energy and Climate initiated in 2009 convenes the European Union and 16 other countries to advance climate change initiatives and ventures.

3.6.2 Mobility schemes for researchers from third countries

The Fulbright Program 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 Program 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 Program has since expanded to more than 155 countries according to the US Department of State. Source: US Department of State, Fulbright Program. Eight thousand scholarships are granted every year. Evaluations of this programme find that it promotes ongoing collaboration, provides a better understanding of the country, and is judged to be valuable and attracts interest in applying for a follow-on Fulbright fellowship. (US State Department 2011)

During the FP6, three out of four of the 303 European researchers who benefited from Marie Curie Outgoing International Fellowships (OIF) went to the US (228 researchers in total) (source: EC FP6 database of contracts).

4 CONCLUSIONS

4.1 *Effectiveness of the knowledge triangle*

US support for research policy reflects the general favourable view of role of the federal government in making science investments. The energy area is a particular priority of the current administration; one of the strategic measures in this area for creating energy breakthroughs is ARPA-E. Innovation policy has seen new activity in the current administration, particularly in multi-agency federal programmes to support “regional innovation clusters” or geographically-bounded concentrations of businesses in technology-intensive industries, as a mechanism to stimulate employment. Education quality is an ongoing concern in the US, although it is primarily the purview of state governments, with the federal government having a somewhat limited role. 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.

Table 4: Effectiveness of knowledge triangle policies

	Recent policy changes	**Assessment of strengths and weaknesses**
Research policy	There has been increased investment and programmes to promote energy research, such as the creation of and funding for ARPA-E.	Support for basic research is more broad-based whereas there is less support for applied research in the US budget. (AAAS 2011) Research policy budgets are less predictable in the current budget crisis. US research policy is based on competition and peer review and is coordinated through the Office of Science and Technology Policy
Innovation policy	There have been several multi-agency programmes that follow a “regional innovation cluster” model, including Energy Efficient Building Systems Regional Innovation Cluster Initiative (E-RIC), and I6 Challenge. In addition, the federal government has authorising legislation to hold prize competitions to address grand challenges.	The US generally has a favourable environment for innovation. (World Economic Forum 2011) However, gaps still remain, for example, in patent reform, which continues to be debated but has not been signed into legislation in recent years. US innovation policy is less coordinated than research policy is.
Education policy	The recent US budget compromise on the fiscal year 2011 includes substantial education cuts including in global exchange programmes, international education, and foreign language study.	Tertiary education is a strength in the US system, while primary and secondary education often compares less favourably with international counterparts. State budget shortfalls mean fewer resources are available to primary and secondary education as well as public universities and colleges.
Other policies	The US Environmental	The US has some strong research programmes

	Protection Agency is issuing regulations under the 1977 Clean Air Act to address greenhouse gas emissions aspects of new facility permitting for large scale utilities and oil refinery projects. (Environmental Protection Agency 2011)	in the energy and environmental area. However, the US has not passed any substantial energy and environmental regulation over the past year, in part because of concerns about the effects of these types of regulations on the economic recovery.

4.2 Comparison with ERA 2020 objectives - a summary

Research: US policies to increase public support for research have received general backing in the re-authorisation in 2011 of the America COMPETES Act. Research support policies are undergirded by strengths in and continued emphasis on quality (via the US peer–review system), highly-ranked US universities, and relatively good access to world-class research infrastructure. In addition, mobilising research to address societal challenges, particularly in the energy area, have become more important in the US system under the current administration. Programmes to support societal response to scientific research are evidenced in small but important initiatives that are part of the National Nanotechnology Initiative. Research capacity questions concerning the distribution of federal R&D investments are addressed in a few programmes such as EPSCoR, but they are very small. Questions about human capital capacities are raised from time-to-time in debates about visa limits and processes.

Commercialisation: The US provides a good environment for research-based commercialisation. Private investment through the SBIR and R&D tax credits face a challenge, however, in that these initiatives have to be regularly renewed. Programmes that appear to direct industry activity attract less support at the federal level, which limits initiatives to promote public-private transfer and knowledge circulation, albeit such initiatives operate in a slightly more favourable climate in the current administration. There is less emphasis in the US system on transitioning to a knowledge-intensive economy and greater concern about re-balancing the economy to stimulate manufacturing jobs.

Coordination: Coordination – including integration of research and joint design of policies – is an ongoing challenge in the decentralised US system. This issue has seen renewed attention in new multi-agency regional innovation cluster programmes as well as existing support in the cross-agency National Nanotechnology Initiative. Coordination between the US and the international community on research issues continues through multiple bilateral and multi-lateral treaties.

Table 5: Assessment of the national policies/measures which correspond to ERA objectives

	ERA objectives	**Relevant national policy actions**	**Assessment of strengths and weaknesses**
1	Ensure an adequate supply of human resources for research and an open, attractive and competitive labour market for male and female researchers	Programmes to encourage international exchange, such as the Fulbright Program (Public Law 584) support, and visa regulations and relevant.	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 has at times limited the

	ERA objectives	Relevant national policy actions	Assessment of strengths and weaknesses
			openness of the US market.
2	Increase public support for research	The America COMPETES Act of 2007 (Public Law 110–69.) which calls for a doubling of the research budgets of three federal agencies and institutes ARPA-E to enable breakthrough energy-related research.	This act was re-authorised in 2011. However, fiscal challenges in the US budget have limited the ability to provide envisioned levels of public support for research.
3	Increase coordination and integration of research funding	The National Nanotechnology Initiative coordinates public investments in nanotechnology across 26 federal agencies.	The decentralised, bottom-up nature of the US policy system, which offers strengths in accessibility, can create difficulties in ensuring coordination and integration.
4	Enhance research capacity	Experimental Program to Stimulate Competitive Research (EPSCoR) programme.	Programs such as EPSCoR provide planning infrastructure and seed research funding which is needed for development of research capacity. At the same time, many of these programmes are rather small in size relative to the total amounts of research funding available.
5	Develop world-class research infrastructures (including e-infrastructures) and ensure access to them	NSF's Major Research Instrumentation Program, which includes the CISE Computing Research Infrastructure.	The US has good research instrumentation funding programmes for small scale instruments but coordination issues and the availability of funding for large scale instruments and operation and maintenance remain at issue. (National Academies 2006)
6	Strengthen research institutions, including notably universities	Aside from programmes such as EPSCoR (which is targeted to US states rather than research institutions) there are no national policies directed at universities.	The US higher education system is large and diverse. It research universities are often at the top of global rankings. (Times 2010) Declines in the US world share of articles continue to be monitored. (National Science Board 2010)
7	Improve framework conditions for private investment in R&D	Small Business Innovation Research Programme. Research and Experimentation Tax Credit	The US has a relatively strong and diverse environment for private R&D investment. However, the effect of the economic downturn on the availability of venture capital and the lack of permanence of the US Research and Experimentation Tax Credit offer opportunities for enhancement.

	ERA objectives	Relevant national policy actions	Assessment of strengths and weaknesses
8	Promote public-private cooperation and knowledge transfer	Technology Innovation Program The University and Small Business Patent Procedure Act (Bayh–Dole Act), Public Law 96-517	The US has a strong and innovative private sector with great capacity to absorb and develop innovations. However, 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.
9	Enhance knowledge circulation	Manufacturing Extension Partnership (MEP)	The MEP programme transfers knowledge to small and medium-sized manufacturers to enhance their competitiveness. The strength of programmes such as these is to provide supply-side knowledge but the US has relatively few demand-side initiatives (e.g., no innovation voucher programmes)
10	Strengthen international cooperation in science and technology	Agreement for scientific and technological cooperation between the European Community and the Government of the United States of America	Establishes a general structure for research and technological collaboration in scientific areas. Other types of agreements are required for scientific cooperation with individual European countries or, in some cases, particular research fields.
11	Jointly design and coordinate policies across policy levels and policy areas, notably within the knowledge triangle	Regional innovation cluster programmes (e.g., Energy Efficient Building Systems Regional Innovation Cluster Initiative, E-RIC, I6)	Although the openness and decentralisation of the US system can be a strength in terms of enabling flexible response to change, it can also pose challenges in terms of joint design and coordination of policies across policy levels.
12	Develop and sustain excellence and overall quality of research	Peer review process	Peer review is the most commonly used method for maintaining research quality, although it has been criticised for sometimes yielding conservative outcomes. (Piore 2011)
13	Promote structural change and specialisation towards a more knowledge - intensive economy	EDA I6 Challenge	Structural change and knowledge-intensive economy promotion are more common at the state than the national level. However, recent national policies concerning regional

	ERA objectives	Relevant national policy actions	Assessment of strengths and weaknesses
			innovation clusters, such as the EDA I6 Challenge, promote development of bioscience and green economies.
14	Mobilise research to address major societal challenges and contribute to sustainable development	The America COMPETES Reauthorization Act of 2010, Public Law No: 111-358, section 105.	Federal agencies are given the authority to award prizes to encourage innovation and address major challenges within the agencies' missions. As this act was just signed into law early in 2011, the processes and outcomes from these types of prizes are untested.
15	Build mutual trust between science and society and strengthen scientific evidence for policy making	Societal Nanoscale Science and Engineering Centers	The National Nanotechnology Initiative has made explicit investments in societal programmes to provide evidence for policy making and foster communication with the public at-large. The National Nanotechnology Initiative budget for these types of programmes has seen substantially greater reductions for societal programmes than for other R&D programmes.

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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	Defense Advanced Research Projects Agency
EERE	Energy Efficiency and Renewable Energy
ERA-NET	European Research Area Network
ERC	Engineering Research Centers
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
NSF	National Science Foundation
PART	Program Assessment Rating Tool
R&D	Research and development
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 Program (TIP)
VC	Venture Capital