INNOVATE AMERICA

December 2004

NATIONAL INNOVATION INITIATIVE REPORT

thriving in a world of challenge and change

Council on Competitiveness

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RESOLVED

Innovation will be the single most important factor in determining America's success through the 21st century.

America's Role

The legacy America bequeaths to its children will depend on the creativity and commitment of our nation to lead a new era of prosperity at home and abroad.

America's Challenge

America's challenge is to unleash its innovation capacity to drive productivity, standard of living and leadership in global markets. At a time when macro-economic forces and financial constraints make innovation-driven growth a more urgent imperative than ever before, American businesses, government, workers and universities face an unprecedented acceleration of global change, relentless pressure for short-term results, and fierce competition from countries that seek an innovation-driven future for themselves.

America's Task

For the past 25 years, we have optimized our organizations for efficiency and quality. Over the next quarter century, we must optimize our entire society for innovation.

CALL TO ACTION

Innovate or Abdicate

The National Innovation Initiative™ (NII) defines innovation as the intersection of invention and insight, leading to the creation of social and economic value.

Innovation has always been deep in America's soul. From the nation's birth, we have most fundamentally been about exploration, opportunity and discovery, about new beginnings, about setting out for the frontier.

America's focus on the horizon reflects our collective faith in a better future. These are the qualities that have made our country a beacon to people around the world for the past 228 years. America, in the end, is all about hope. And innovation is the societal and economic manifestation of hope.

Today, America finds itself at a unique and delicate historical juncture, shaped by two unprecedented shifts – one in the nature of global competition, the other in the nature of innovation itself:

1. The world is becoming dramatically more interconnected and competitive. At the same time that economic interdependencies are growing, America is in the unfamiliar position of the world's sole superpower. It is important to recognize how novel this situation is historically, and what opportunities and dangers it holds – from rivals or potential rivals, to be sure, but perhaps even more from how we ourselves choose to handle this geopolitical reality.

2. Where, how and why innovation occurs are in flux – across geography and industries, in speed and scope of impact, and even in terms of who is innovating. In many ways, the playing field is leveling, and the barriers to innovation are falling. Whenever such a shift occurs, there are always changes in how economies and societies work – including new ways of creating value and measuring success, and realignments of competitive advantage. In the 21st century, the pace of these changes will accelerate. To thrive in this new world, it will not be enough – indeed, it will be counterproductive – simply to intensify current stimuli, policies, management strategies and to make incremental improvements to organizational structures and curricula.

Together, these large shifts suggest that we stand at an inflection point in history. Whether one looks at demographics, science, culture, technology, geopolitics, economics or the biological state of the planet, major changes are underway that will shape human society for the next century and beyond. The actions that enterprises, governments, educational institutions, communities, regions and nations take right now will determine this future.

What will America do? Will we plan and invest for the long term, rather than just the next quarter, putting in place the talent pool, innovation capital and infrastructure necessary for continuing success throughout the 21st century? Will we recognize the multifaceted nature of this problem and come together across all sectors – business, government, labor and academia – to form a new social and economic compact?

Perhaps most important is whether the United States will continue its historic and unique role as a leader among nations, exporting the vision and tools of hope and the power of innovation. America must champion and lead a new era of openness and competition – fueled by agility and constant motion, and enabled by lifelong learning, technological prowess and the infinite creativity of the innovation process itself.

We live in tumultuous times, yet Americans know instinctively that our way forward is not to retreat or to re-trench. The way forward is to become more open, more experimental and to embrace the unknown. We cannot turn inward, nor can we allow our institutions to become overly centralized, calcified and risk averse.

If America were a company, freedom and exploration would be our core competencies. And the capacity to innovate is the foundation

for bringing our competitiveness into full fruition. The first Americans were innovating when they made the decision to leave an established life for the perils of an unknown world. They were innovating before we had government, a functioning economy, an educational system or national defense. In short, if Americans stop innovating, we stop being Americans.

In the end, the simplest way to describe the purpose of the National Innovation Initiative is to help focus us as a society on what we do best, on our purpose in history. The key to America's future success, finally, is to remember who we are.

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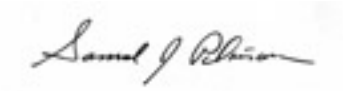

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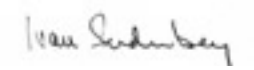

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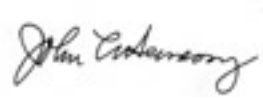

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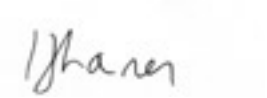

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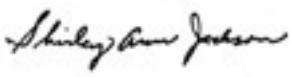

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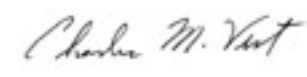

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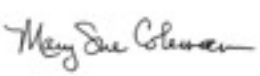

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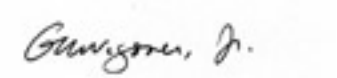

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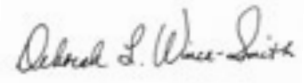


The Honorable Deborah L. Wince-Smith
President
Council on Competitiveness

EXECUTIVE SUMMARY

The National Innovation Initiative recommendations are organized into three broad categories:

Talent

The human dimension of innovation, including knowledge creation, education, training and workforce support. Recommendations support a culture of collaboration, a symbiotic relationship between research and commercialization, and lifelong skill development.

Investment

The financial dimension of innovation, including R&D investment; support for risk-taking and entrepreneurship; and encouragement of long-term innovation strategies. Recommendations seek to give innovators the resources and incentives to succeed.

Infrastructure

The physical and policy structures that support innovators, including networks for information, transportation, healthcare and energy; intellectual property protection; business regulation; and structures for collaboration among innovation stakeholders. Recommendations support a new industry-academia alliance, an innovation infrastructure for the 21st century, a flexible intellectual property regime, strategies to bolster the nation's manufacturing enterprises, and a national innovation leadership network.

National Innovation Agenda

Talent

Build a **National Innovation Education Strategy** for a diverse, innovative and technically-trained workforce

- Establish tax-deductible private-sector "Invest in the Future" scholarships for American S&E undergraduates
- Empower young American innovators by creating 5,000 new portable graduate fellowships funded by federal R&D agencies
- Expand university-based Professional Science Masters and traineeships to all state university systems
- Reform immigration to attract the best and brightest S&E students from around the world and provide work permits to foreign S&E graduates of U.S. institutions

Catalyze the **Next Generation of American Innovators**

- Stimulate creative thinking and innovation skills through problem-based learning in K-12, community colleges and universities
- Create innovation learning opportunities for students to bridge the gap between research and application
- Establish innovation curricula for entrepreneurs and small business managers

Empower **Workers to Succeed in the Global Economy**

- Stimulate workforce flexibility and skills through lifelong learning opportunities
- Accelerate portability of healthcare and pension benefits
- Align federal and state skills needs more tightly to training resources
- Expand assistance to those dislocated by technology and trade

Investment

Revitalize **Frontier and Multidisciplinary Research**

- Stimulate high-risk research through "Innovation Acceleration" grants that re-allocate 3 percent of agency R&D budgets
- Restore DoD's historic commitment to basic research by directing 20 percent of the S&T budget to long-term research
- Intensify support for physical sciences and engineering to achieve a robust national R&D portfolio
- Enact a permanent, restructured R&E tax credit and extend the credit to research conducted in university-industry consortia

Energize the **Entrepreneurial Economy**

- Build 10 Innovation Hot Spots over the next 5 years to capitalize on regional assets and leverage public-private investments
- Designate a lead agency and an inter-agency council to coordinate federal economic development policies and programs to accelerate innovation-based growth
- Increase the availability of early-stage risk capital with tax incentives, expanded angel networks, and state and private seed capital funds

Reinforce **Risk-Taking and Long-Term Investment**

- Align private-sector incentives and compensation structures to reward long-term value creation
- Create safe-harbor provisions to promote voluntary disclosure of intangible assets
- Reduce the cost of tort litigation from 2 percent to 1 percent of GDP
- Convene a Financial Markets Intermediary Committee to evaluate the impact of new regulations on risk-taking

Infrastructure

Create **National Consensus for Innovation Growth Strategies**

- Enact a federal innovation strategy through the Executive Office of the President
- Catalyze national and regional alliances to implement innovation policies and innovation-led growth
- Develop new metrics to understand and manage innovation more effectively
- Establish National Innovation prizes to recognize excellence in innovation performance

Create a **21st Century Intellectual Property Regime**

- Build quality in all phases of the patent process
- Leverage patent databases into innovation tools
- Create best practices for collaborative standards setting

Strengthen **America's Manufacturing Capacity**

- Create centers for production excellence including shared facilities and consortia
- Foster development of industry-led standards for interoperable manufacturing and logistics
- Create Innovation Extension Centers to enable SMEs to become first-tier manufacturing partners
- Expand industry-led roadmaps for R&D priorities

Build **21st Century Innovation Infrastructures – the health care test bed**

- Expand electronic health reporting
- Establish and promote standards for an integrated health data system
- Establish pilot programs for international electronic exchanges on healthcare research and delivery
- Expand use of performance-based purchasing agreements

I

INNOVATION OPPORTUNITIES AND CHALLENGES

Today, America competes and collaborates in an interconnected world.

- We compete and collaborate in a global trading system in which the consensus for free and open markets is fragile and the market share for high-value products and services is increasingly being driven by discriminating consumers, not protected producers.
- We compete and collaborate globally to attract the best and brightest minds and managerial talent who will develop the new knowledge and create the disruptive technologies that will launch new industries and re-shape competitive advantage with profound import for nations, industries, firms and individuals.
- We compete and collaborate in a world in which the power of networked communications, the extended manufacturing enterprise and access to low-wage talent has enabled the outsourcing of both low and high-skilled jobs.
- And we compete and collaborate in a post-Cold War security environment in which, for the first time in our history, the United States must protect its citizens and homeland from asymmetrical threats from terrorist groups and rogue nations which have the technological means to wreak havoc on advanced economies and destroy millions.

While America competes and collaborates across global economic and security arenas, we must never forget that the most important competition is being fought in the arena of ideas, learning, and delivering new kinds and levels of value to the marketplace.

America's ultimate source of national and individual prosperity, homeland security and leadership in the world is an unstoppable, fertile, open and inclusive economy. From the schoolroom to the campus and community college, to the halls of government, across our urban and rural communities, and to the world's markets, America must unleash a new era of innovation-driven growth.

Innovation generates the productivity that economists estimate has accounted for half of U.S. GDP growth over the past 50 years.[1] Innovation gives rise to new industries and markets; fuels wealth creation and profits; and, generates high-value, higher-paying jobs. In a world in which many nations have embraced market economies and can compete on traditional cost and quality terms, it is innovation – the ability to create new value – that will confer a competitive edge in the 21st century.

Innovation also improves the quality of our lives in countless ways – offering new forms of convenience, customization and entertainment. It's not only about offering new products and services, but also improving them and making them more affordable.

But most important, innovation has always been the way people solved the great challenges facing society. Today, innovations not yet imagined, in areas ranging from science to politics, education to business, will enable us to achieve dramatically higher levels of health across the planet; develop productive options for a rapidly aging population; find plentiful, affordable, environmentally-friendly sources of energy; spread democratic approaches and win the war against terrorism; and, expand access to the knowledge that can enable a more secure and satisfying future.

America today is a clear No. 1 in productive innovation. The United States remains near the top rank of countries measured by R&D as a percentage of gross domestic product.[2] America is still the world leader in venture capital and is home to many of the finest research labs and universities. Our workforce is talented, more flexible and mobile than those of most countries. We possess one of the most open economies for trade and investment; a stable government; a strong technology base; and, a culture uniquely supportive of risk-taking.

We stand on a strong foundation.

However, that foundation can be shaken.

On the macro-economic front, the United States faces a widening savings deficit. We spend more than we save and import more than we export – as individuals as well as a nation. Cumulative budget deficit projections for 2005-2014 are expected to total $2.3 billion, according to the latest Congressional Budget Office forecast. And these pressures will only intensify with the retirement of the Baby Boomers that is expected to incur billions and eventually trillions of dollars of unfunded liabilities. As deficits rise, the availability of risk capital tightens.

Similarly, the trade deficit is now approaching $650 billion this year. As Alan Greenspan noted, while single year deficits are not insurmountable, multiyear, cumulative deficits begin to raise more complex issues. Historically, America has imported capital from the rest of the world to finance not only consumption, but also investment. The concern is that foreign investors may begin to diversify substantially their holdings away from dollar assets and find other opportunities for their global investments. China, for example, surpassed the United States this year as the largest recipient of foreign direct investment.

Certainly, we can and should do more to increase savings and hold down spending. But equally, if not more, important is economic growth – and innovation provides the fuel for economic expansion. To attain higher levels of innovation-driven growth, we must take stock of where we are and where we want to go.

What are the most important changes and factors to take into account in shaping America's innovation agenda? We believe there are three:

1 The new shape of innovation

We believe that the bar for innovation is rising. And, simply running in place will not be enough to sustain America's leadership in the 21st century. Innovation itself – where it comes from and how it creates value – is changing.

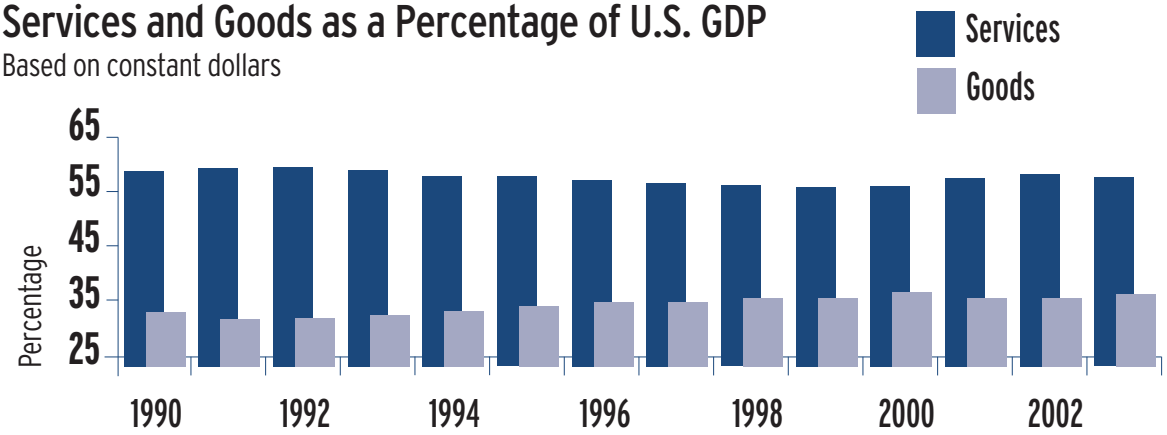
- It is diffusing at ever-increasing rates. It took 55 years for the automobile to spread to a quarter of the country, 35 years for the telephone, 22 years for the radio, 16 years for the PC, 13 years for the cell phone, and only seven years for the Internet.[3]
- It is multidisciplinary and technologically complex. It arises from the intersections of different fields or spheres of activity.
- It is collaborative – requiring active cooperation and communication among the scientists and engineers and between creators and users.
- Workers and consumers are embracing new ideas, technologies and content, and demanding more creativity from their creators.
- It is becoming global in scope – with advances coming from centers of excellence around the world and the demands of billions of new consumers.

The innovation economy is fundamentally different from the industrial or even the information economy. It requires a new vision, new approaches and a new action agenda. The United States must create the conditions that will stimulate individuals and enterprises to innovate and take the lead in the next generation of knowledge creation, technologies, business models and dynamic management systems. A new relationship among companies, government, educators and workers is needed to assure a 21st century innovation ecosystem that can successfully adapt and compete in the global economy.

2 The seriousness of the competition

America's economic and political standing are fundamentally bound up in our capacity as a society to innovate, and we now face much more serious competitive challenges from new centers of innovation across an increasingly interconnected planet.

Figure 1



Source: Bureau of Economic Analysis

The rest of the world is picking up the pace...

- Foreign owned companies and foreign-born inventors account for nearly half of all U.S. patents with Japan, Korea and Taiwan accounting for more than one-fourth.[4]
- Sweden, Finland, Israel, Japan and South Korea each spend more on R&D as a share of GDP than the United States.[5]
- China overtook the United States in 2003 as the top global recipient of foreign direct investment.[6]
- Only six of the world's 25 most competitive Information Technology companies are based in the United States; 14 are based in Asia.[7]
- Asia now spends as much on nanotechnology as the United States.[8]

While America relies upon a past commitment to its knowledge economy...

- Federal funding, a mainstay of discovery research, has been in long-term decline, now only half of its mid-1960s peak of 2 percent of GDP. Excluding spending on defense, homeland security and space, federal investment in fundamental research is expected to decline in real terms over the next five years.
- Corporate R&D dropped nearly $8 billion in 2002, the largest single year decline since the 1950s.[9]
- Total scientific papers by American authors peaked in 1992 and have been flat ever since.[10]
- The service sectors, that represent more than half of U.S. economic activity,[11] lack the underpinning of robust research investment into innovative business process design, organization and management. (See Figure 1)
- Manufacturing has not been sufficiently linked up to the new sciences and technologies – emerging fields like nanotechnology, multifunctional materials, and process design – that could revitalize America's competitiveness.

The evidence is clear. While we remain the world's leader, the capacity for innovation is going global – and we must pick up the pace. The reality of a new competitive dynamic should not be unfamiliar territory. During the 1980s, the United States faced a similar challenge from Japan. To restore their competitive position, U.S. businesses, in concert with government policy-makers and business school theorists, developed the new management tools to transition successfully from a mass production to a quality-management culture.

Today, the forces of global economic integration and advances in technology are creating a different and more complex challenge. Sustaining competitive advantage will require moving beyond efficiency and quality toward creating new markets, increasing choice and value to customers, and innovating continuously on a global basis.

3 The scope of the opportunity

In the end, the importance of innovation lies less in competitive victory of one country over others than in building a better world for everyone. America can be an engine of change and a driver of prosperity. We see the promise of a better future for our children – and the world's children.

- We see the promise of environmentally friendly and plentiful sources of energy to drive growth. If just 1 in 100 cars and trucks in the United States were fueled by hydrogen, 4 million gallons of gasoline could be saved every day.[12]
- We see the promise of new medical therapies that cure disease, rather than simply treating its symptoms. More than 325 million people worldwide have been helped by bio-technology-based drugs and therapies – and of all the biotech drugs on the market today, over 70 percent were approved in just

21st Century Innovation Opportunity — the Hydrogen Economy

The potential of a hydrogen economy to address major challenges facing America and the rest of the world is capturing the imaginations of consumers, researchers, government and industry.

Why hydrogen? There are many compelling reasons. According to Larry Burns, Vice President, Research & Development and Planning for General Motors Corporation:

- A hydrogen fuel cell vehicle is nearly twice as energy efficient as a conventional vehicle, and its only emission is water vapor.
- Hydrogen can be extracted from various fuels, promoting energy diversity.
- The introduction of alternative energy sources should decrease petroleum dependence and increase energy security, and could make energy pricing more competitive.
- Fuel cells will enable the auto industry to reinvent the automobile itself. They are the foundation for innovative and compelling vehicle designs that show great promise of being affordable, sustainable, and profitable.
- Fuel cells are a potential source not only of transportation power, but also of electrical power. They could enable new, more environmentally compatible, distributed electric-power generation.

the last four years.[13] The promise of genomics and proteomics is to move healthcare beyond reactive, or even preventive, to predictive.

- We see the promise of lower-cost and higher-quality health care by applying 21st century information technologies. With nearly a third of healthcare dollars tied up in administrative paperwork, the potential savings are in the hundreds of billions in the United States alone.[14] Patients will be afforded more control over their own health information through secure, private and portable medical records, while research into new cures can be expanded to and improved by a global network. This interconnection of distributed medical facilities, data and expertise, combined with highly personalized care, holds enormous promise for both individual and societal health.

- We see a future in which homeland security efforts can actually enable productivity gains and economic growth. For example, IT-based identification, tracking and verification systems to monitor cargo will also enable just-in-time logistics across secure borders. Sophisticated electronic and biometric access control safeguards could reduce the administrative paperwork of time, attendance and payroll data, and allow workers to devote themselves to more productive pursuits. Sophisticated data mining tools, combined with sensors, software and supercomputers, could derail attacks on our infrastructure in real time.

- We see the promise of a profound revolution in manufacturing through the development and use of transformational technologies such as nano-scale materials and devices. Nanotechnology could impact the production of virtually every human-made object – from vehicles to electronics to medical technology – and will lead to economical, low-volume manufacturing that can custom fit products for every conceivable use. Nano-manufactured medical devices, including nano-particles, will detect and treat disease in a manner that revolutionizes health diagnostics and cures.[15]

- We see the promise of new industries and better jobs, so that America isn't building walls to keep jobs in, but becoming a creative epicenter for new ones and a magnet for global talent. The 42 industries represented by the Council on Competitiveness alone are projected to create nearly 13 million jobs by 2006 and nearly 100 million jobs worldwide over the next decade.[16] The preponderance of those jobs will be the result of innovations that are occurring, and will occur with increasing frequency, around the world. Whether those jobs are here in America will be up to us.

In the end, the challenge to the United States is to respond to the historic shifts of our age by optimizing American society for innovation. This report proposes some early-stage ideas for how to do that – and the National Innovation Initiative itself is one model for how such collaborative, cross-societal efforts can mobilize our nation's innovation resources to drive us forward to a better future.

More than 400 leaders and scholars from universities, corporations, professional societies, industry associations and government agencies joined in October 2003 to form the NII. These subject-matter experts have been engaged in working groups for the past 15 months on initiatives to create a new compact among companies, government, educators and workers to assure a 21st century innovation ecosystem. Our recommendations address the need for new forms of collaboration, governance, measurement – and a new sense of purpose and mission – that enable America's workers to succeed, not merely survive, in the global economy, that restore America's uniquely positive culture of risk and reward, and that create new societal mechanisms to drive the pace and quality of the national innovation enterprise.

II

THE NEW SHAPE OF INNOVATION

When we say that innovation isn't what it used to be, we are not simply referring to its speed, ubiquity or importance. We believe that innovation at the dawn of the 21st century is actually happening in new ways.

Relationships that once looked adversarial are increasingly evolving into complementary, even symbiotic ones. Customers and producers are engaging in a process of co-creation. Intellectual property ownership and openness both now drive innovation capacity. The lines between manufacturing and services are blurring. The contributions of small businesses to the innovation economy rival those of large ones. Public sector innovation is now an important part of what was once considered the preserve of the private sector. "Expertise" used to mean In-depth knowledge of a particular discipline, but now it must be multi-disciplinary, since innovation occurs at the intersections of disciplines between research and its end-use applications.

It is these types of changes – in relationships among innovators and in the nature of innovation itself – that create the impetus behind the new policy architecture proposed by the NII. Some of the most salient new relationships include the following.

- User and Producer-Based Innovation
- Proprietary and Public Domain Intellectual Property
- Manufacturing and Services
- Established Disciplines and Multidisciplinary Research Programs
- Public and Private-Sector Innovation
- Small and Large Firms
- Security and Scientific Openness
- Nationalism and Globalization

User and Producer-Based Innovation

In the industrial model, the world was divided into "producers" and "consumers," with the former in control. But today, the center of gravity is shifting as innovation increasingly occurs on both sides of the cash register.

User-based innovation, to borrow a term coined by MIT's Eric von Hippel, calls into question the whole notion of the passive consumer. Probably the most difficult, costly and time-consuming piece of a company's innovation process is identifying customer needs. However, new models of innovation incorporate the customer into the design and development process. Semiconductor manufacturers now provide customers with specialty software to design their own chips. A global supplier of specialty food flavors has built a tool kit that enables customers, like Nestle, to create their own flavors. Plastics manufacturers such as GE offer web-based tools to their customers to develop improved plastic products.[17]

User-based innovation opportunities extend beyond companies to individuals, as well. Software developers are exploring new business models that encourage users to add value at every stage from design and development to execution, support and upgrades – with thousands of volunteers to validate and de-bug the code. Game manufacturers have created portals that allow enthusiasts to design their own video games. On-line auctions like eBay combine existing systems – the Internet, credit cards and package delivery – in ways that empower millions of home-based entrepreneurs. And products like desktop publishing are creating new opportunities for users to become innovators themselves.

This shift toward reciprocal innovation between producer and user can sharpen the process, help manage risk and significantly mobilize the nation's innovation capabilities. We have traditionally venerated the idea of the lone genius – from da Vinci, to Confucius, to Einstein – as the prime source of creativity. Now, innovation co-creation can turn us from a nation that supports and celebrates innovation into a nation of innovators.

Biotechnology's Innovation Impact

Biotechnology is transforming industry and revolutionizing the war against disease. Biotechnology is any technique that uses living organisms or their products to make or modify a product, to improve plants or animals, or to develop microorganisms for specific purposes. The science of biotechnology is applied in manufacturing, agriculture and medicine.

Today, biotechnology is saving lives and holds the promise of breakthrough solutions for many of the devastating diseases and conditions for which there are currently no treatments. Already, the more than 155 biotechnology drugs and vaccines available today have helped more than 325 million people worldwide. Leading the way in creating innovations that dramatically improve lives, companies like Amgen have transformed treatment paradigms for patients with cancer, kidney disease and inflammatory diseases. The impact from biotechnology's innovation can be seen in many places:

- Cancer patients are living longer and fuller lives
- HIV results can be processed in just 10 minutes
- For the first time, the debilitating course of Multiple Sclerosis can be altered
- Joint damage caused by rheumatoid arthritis can be reduced and pain virtually eliminated for many.

Source: Biotechnology Industry Organization

Proprietary and Public Domain Intellectual Property

Since the founding of our republic, the protection of intellectual property has been one of the underpinnings of American society and our innovation system. Patents guarantee that inventors have the opportunity to benefit from their creations. Such IP protection has become even more important in the global economy. Intangible assets today represent about 85 percent of the market value of the companies on the S&P 500 and, by extension, a large part of the U.S. export market.[18]

IP protection is particularly important for start-ups. Without clear title to intellectual property, entrepreneurial start-ups are less able to obtain seed or venture capital for commercialization. In a world of rapid, relentless innovation and competition for ideas, entrepreneurs and large companies alike view their intellectual property as both a treasure and a time-sensitive vulnerability.

At the same time, the evolution of the innovation enterprise – the trend toward user co-creation, the need for interoperability in complex IT networks and revolutionary advances in understanding about human biological networks – is putting pressure on traditional IP models and strategies.

In biology, for example, knowledge breakthroughs in genomics have transformed state-of-the-art research. The reductionist biology of the 20th century, which focused on individual components, is giving way to a systems approach that seeks to understand how the genetic building blocks work together in bio-networks. To understand systemic interactions, researchers need access to a broad range of scientific data, covering the genome, RNA and protein sequences and structures. While the issue of intellectual property ownership is far from resolved, a number of public and private entities are contributing proprietary and patented research into publicly accessible, international databases like GenBank, to assure future innovation.

IP collaboration is becoming an increasingly critical tool for IT innovation as well. No single organization has the scale to build today's complicated systems, but a single entity can inhibit or block access to IT networks through control of patent portfolios and prohibitive rents. More broadly, the need for interoperability – linking the patchwork-quilt arrays of legacy systems within most large enterprises and between systems of distinct firms – has resulted in a shift towards open standards, coupled with development of new middleware tools to enable this connectivity. Standards, like TCP/IP – the transmission protocol that makes the Internet work – have created an extraordinary platform for innovation of new technologies, markets, industries and business models.

The protection of and global respect for IP are now more critical than ever. But optimizing for innovation will likely require an evolutionary but deliberate shift in IP systems and standards – including patent pools, open access databases, open standards, flexible and affordable cross-licensing, multi-jurisdictional patents and harmonized patent systems – that can be tailored to rapidly evolving technology and knowledge networks.

Manufacturing and Services

According to conventional wisdom, just as industrialization led to a dramatic reduction in agricultural jobs, the growth of the services sector will drive out manufacturing. However, this fails to take account of profound changes underway in the manufacturing sector. Although we may measure them separately in our statistics, the reality is that manufacturing operations increasingly and inextricably combine production and services.

Because of the IT revolution – especially in software – a major component of manufacturing is service-based. As the U.S. Congress Office of Technology Assessment noted: "Software is … a marriage of manufacture and service, since it has the character of both a good (it can be stored and shipped) and a service (computer programs are not immutably fixed)."[19] But, we classify software as a service, not a manufacture. Consider how it is being applied:

- Manufacturers like Xerox are installing service capabilities in their machines – diagnostic software that is capable of signaling to the manufacturer when a part is nearing the end of its useful life, before the problem is ever visible to the customer.[20]

- In 1985, when Ford Motor Company wanted safety data on its vehicles, it spent $60,000 to slam a vehicle into a wall. Today, that frontal crash is performed virtually on high performance computers – at a cost of around $10.[21]

- To design the 777, Boeing developed a software program that allowed its engineers to "fly" in a computerized prototype of the aircraft and iterate the design in virtual space.[22]

- Wal-Mart has installed miniature tracking devices on its products, enabling computerized inventory tracking and controls.

Competitive companies are bundling production and services – and for good reasons. With the rapid pace of technology diffusion, even advanced products can be quickly commoditized. Integrating services into the mix changes the value hierarchy and transforms the revenue stream.

- Jet engine manufacturers, like GE Aircraft, Pratt & Whitney, Rolls Royce and Honeywell Aerospace do not just sell engines and spare parts; they sell propulsion services. Why? Because the value of services on a product through its life span can exceed original sales by as much as five times.[23]

- In the wireless industry, the profits do not come from the devices but from the service. And increasingly service offerings are shifting from voice service, which is now a commodity, to data services.[24]

- IBM remains the largest computer manufacturer in the world, but its fastest growing business segment is in IT services.

Manufacturing companies are transforming themselves from product suppliers into solutions providers – and melding services seamlessly into their product lines. The manufacturing strategies introduced over the past two decades of lean, Six Sigma-esque continuous productivity and quality improvement are no longer a source of meaningful competitive advantage. They are the minimum requirements to be in the game. Going forward, winning will depend on customization, flexiblity, speed and innovation, not competing in a low-wage, mass-production system.

Established Disciplines and Multidisciplinary Research Programs

Historically, advances in knowledge came through the efforts of individual investigators with specific disciplinary specialties, such as – chemistry, biology, physics or mathematics. Today, however, innovation tends to occur more frequently at the intersection of disciplines and, indeed, sometimes drives the creation of entirely new ones, such as nanobiology, network science or bioinformatics.

Advances in medical technologies integrate biology with physics, mathematics, materials sciences and software engineering. Innovation in the IT sector is built on research that spans a range of sciences, including solid-state physics, chemistry, mathematics and language theory – and increasingly, social sciences and the unique dynamics of particular industries, as IT planning becomes integral with business and organizational strategy.

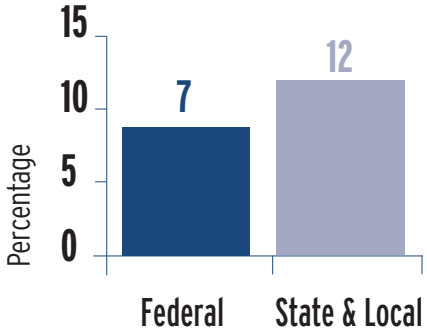
At issue is not a choice between single discipline specialization and multi-disciplinary research. The ability to innovate at the intersection of disciplines, by definition, implies the need for strong disciplinary expertise. But, knowledge silos simply won't drive innovation in a much more interconnected world. Indeed, they will inhibit it.

The changing nature of innovation demands new knowledge and learning networks that can facilitate communications and collaboration at the frontiers of many disciplines and that can cross organizational boundaries between academia, industry and government.

Figure 2

Govt. Outlays as Share of GDP, 2003

Excluding tax & transfer payments



Source: U.S. Commerce Department

While academia has been exploring interdisciplinary approaches for decades, and while there has been progress, such multidisciplinary efforts at universities remain insufficient – and have yet to emerge as a core focus of the national research enterprise.

Public and Private Sector Innovation

Conventional wisdom holds that innovation is a process conducted mainly by private entities, with government restricted to setting the rules and creating or supporting the necessary infrastructure. That role is, of course, essential – as is clear when one considers the impact on innovation and economic growth of education policy, financial regulation, research investment, tax rules, bankruptcy laws, intellectual property protection, and infrastructure investment. However, government today is increasingly and more intimately involved in innovation beyond its role as a referee or systems integrator.

To put this in perspective, consider the public sector in economic and human terms. Government purchases and investments account for almost 19 percent of U.S. gross domestic product (see Figure 2);[25] and more than 16 percent of the U.S. workforce is made up of government employees.[26] Such an enormous swath of activity must be productive and efficient – and it must be innovative – if America is to prosper and compete in the 21st century. Regardless of the speed at which the American private sector innovates, overall economic growth will be limited by the speed of government innovation.

There are many opportunities for positive change. For example, government can accelerate the use of competition in achieving its mission. These kinds of process innovation, where government competes with private enterprises for certain services, have improved performance at dramatically lower cost – often exceeding 30 percent savings.[27] Those savings can be used to serve more people, invest in further innovation or reduce tax burdens – all of which create value for citizens. And there are many other ways in which government can adopt private-sector approaches – such as e-government initiatives and the use of performance standards – to create new value for citizens.

Government can also accelerate its historical role as a driver of innovative technologies and services. America's defense and space programs, for example, push technology in many and new directions, and create a first-adopter dynamic. Government missions generate demand and resources for innovation.

Perhaps most important, government can take on long-range, strategic projects beyond the reach of the private sector. Without the pressure of quarterly results, government can address societal challenges that require more capital or entail higher risk than the private sector may be able to support. Major innovations like the Internet and global positioning are recent examples where government served as the catalyst for technologies that now dramatically impact our economy and daily lives.

Small and Large Firms

When we think of innovation, we often think of big companies – Dupont and nylon, Boeing and the 777, IBM and the mainframe, Microsoft and Windows. Fully 75 percent of the nearly $200 billion of industrial R&D investments in the United States are made by firms with 1,000 employees or more.[28]

But despite their significant investment in R&D, large firms are often not the source of new-to-the-world technology. Big firms often tend to focus on making their existing product lines better and more affordable, while smaller firms are more likely to invest in radical innovation. Lewis Branscomb points out that only about $16 billion – or eight percent – of large firm R&D expenditure goes to radical innovation.[29] In comparing the patenting activities of small, serial innovators and large firms, CHI Research has found that:

- Small-firm innovation is twice as closely linked to scientific research as for larger firms, and it is more technically important.
- Small firms' patents are at least twice as likely to be found among the top one percent of high-impact patents.

- Small firms are more effective in producing high-value innovation.[30]

These trends highlight a new interdependent relationship between large and small companies. As access to empowering technology, knowledge and markets has become increasingly widespread, barriers to entry have fallen. Firm activity has become much more dynamic. Small companies can grow very rapidly – and just as rapidly, large companies can collapse. There were 100,000 start-ups in America in 1950; by 2000 there were 800,000. The average yearly business failures went from 10,000 in 1978 to 100,000 in 1994.

In this increasingly fluid environment, no one company can hope to achieve and maintain control of an industry or market through vertical integration. Even the largest businesses, governments and academic institutions are more and more interdependent with a large number of smaller enterprises. As Harvard's Marco Iansiti has described, the relationships among enterprises large and small are starting to resemble those of biological ecosystems.[31] In that context – in a world of "keystones" and "niches" – size remains important, but it is no longer the key determinant for success. Position, expertise and the strength of collaborative relationships become as important for a company's profitability.

This interdependence is particularly relevant in the context of the innovation enterprise. Big and small companies have increasingly complementary roles in technology development. Consider pharmaceutical giants Pfizer and Merck, for example. Both have research and development budgets in the billions and internal teams and labs spread throughout the world. However, they also rely on hundreds of research partnerships with smaller companies and research firms. Increasingly, they look to small biotech firms to do the initial research and development on pharmaceutical products, and then license the technology or buy the company. Microsoft, the world's largest software company directly employs tens of thousands of software programmers. They also use an army of globally disperse subcontractors to help improve and develop products.

Frequently small companies have deep expertise in niche skills but little skill or experience in working in large teams or managing complex projects. Large companies often have very broad technology portfolios, but insufficient depth in specific technical areas. They often are expert at managing complex projects and can link up teams of people with disparate cultures, languages, skills and business process approaches. Small companies may be able to respond more quickly to customer needs or quick market changes while large firms can offer very broad supplier and customer networks. As a result, technology partnerships and collaborations between large and small companies make good partners because the strengths of one are the weaknesses of the other.

The reality is that the innovation economy needs both incremental and breakthrough innovation, both large and small innovators. As William Baumol notes, this is no David and Goliath story. The different roles taken on by small and large firms together create more technological progress, innovation and growth than either category could have achieved by itself."[32]

Security and Scientific Openness

In a global, innovation-based economy, it is becoming more and more necessary to engage globally, in order to keep up with the frontiers of knowledge and attract the best talent. Yet fears that knowledge could fall into the wrong hands – possibly to be used against us – or even that foreign students might pose an unacceptable risk to America are altering the balance between America's historic scientific openness and our security imperatives. Finding the right balance will be absolutely critical to America's innovation enterprise.

For decades, the best and brightest have flocked to the United States to take advantage of our world-class education, and to participate in a culture that welcomed newcomers and enabled them to contribute in industry, academia and government. Many have stayed to create breakthrough research and launch new companies. Indeed, one-third of today's U.S. workforce of scientists and engineers were

born outside the United States.[33] But new immigration controls have resulted in a 32 percent drop in the number of international student applications in 2004,[34] and the number of foreign students whose visas were rejected rose to 35 percent.[35]

Looking out to the future, the Educational Testing Service finds that the number of foreign students applying to take the GRE test – a pre-requisite for admission to a U.S. graduate program – has declined by one-third.[36] For the first time in our history, the United States is confronting the possibility of a reverse brain drain – with innovators, scientists and engineers taking advantage of the growing opportunities for world-class education and research outside our borders.

In the same way, our leadership in research is being affected by security concerns. Research is subject to an array of regulations regarding foreign nationals, potentially forcing universities to apply for thousands of export licenses annually.

Innovation capacity and homeland security are, in reality, tightly coupled. There can be no security without the economic vitality that innovation creates, just as there can be no economic vitality without a secure environment in which to live, work and create. These are, to be sure, early days in how our society responds to new kinds of threats, but we are still searching for a balance between scientific exploration and security.

Nationalism and globalization

In a world that is evolving from an "international" order to truly global interconnectedness, the best way to increase national innovative capacity is to engage actively and collaboratively with the rest of the world. No nation can corner the market on innovation. We should welcome the improvements in other nations' capabilities to grow and prosper. Their people deserve to participate fully in the rising global tide of innovation-driven prosperity. And it is truly a win-win. Prosperity abroad creates multiplier effects that are positive for America and Americans.

Our security and economic opportunities are enhanced by growing economies around the world, not by societies locked in poverty without a stake in the global order. The recommendations of the National Innovation Initiative are designed to focus on how America can create win-win solutions that improve our own innovation capacity and national competitiveness while engaging actively and collaboratively with the rest of the world.

This convergence of formerly separate or even opposed forces – innovation users and creators, public and private stakeholders, IP ownership and open standards collaboration, small and large businesses, and a host of other new, reciprocal relationships – has profound implications for public policy, for business strategy and for academic curricula. These kinds of changes in the nature of innovation – how, where and through whom it occurs – create a real urgency for new and comprehensive approaches to strengthening the nation's innovation enterprise. They are the rationale behind the NII Call to Action and the key to understanding why simply intensifying current stimuli and polices will not be enough to assure U.S. economic leadership in the 21st century.

III

THE INNOVATION ECOSYSTEM

Innovators start with an idea of what is needed by a society, market or individual. Like inventors, they create – but they also apply their creations. And those applications, in turn, generate further innovations, giving rise to new industries and national and global markets; spurring productivity and economic growth; fueling wealth creation and profits; generating high-value, higher-paying jobs; and raising the standard of living, not just for direct beneficiaries of those new jobs, but also for other people touched by the innovation.

In order to develop an effective national innovation strategy, we have to understand the way innovation actually occurs. America's broad direction – and the particular actions of government, business and academia – need to be based on the contemporary reality of this complex, dynamic phenomenon. Innovation is best seen not as a linear or mechanistic process, but as an ecosystem, a multi-faceted and continual interaction among many aspects of our economy and society.

Addressing individual parts of this ecosystem as if they were discrete problems would be insufficient and ultimately ineffective. Along with the NII's particular recommendations, one of the most important outputs of our work over the past year is our proposal for an overarching architecture for innovation. Treating the ecosystem as an ecosystem is inherent in what we mean by "optimizing for innovation."

The most common conception of innovation is a linear progression from research to invention and from invention to commercialization. But this framework makes it clear that the dynamics of innovation are a lot more complex. It is not just the sum of knowledge inputs. As illustrated in Figure 3, our perspective needs to be holistic – including not only the important supply inputs to innovation but also market demand and the influence of external factors, especially the policy environment and the common national infrastructure.

These factors, individually and as a system, make up the context in which the nation's enterprises innovate. And though the private sector takes the lead – applying strategies, technologies, business models, and capital that address genuine market needs – the model suggests how the overall strategic direction and quality of the innovation ecosystem drive value creation and the nation's performance.

Consider the key dynamics implicit in this framework:

Supply and demand

Innovation policy in the past has tended to focus more on supply (inputs such as research, skills, management strategies, knowledge and risk capital) than on demand – (outputs valued by societies such as quality, security, convenience and efficiency). The framework for the National Innovation Ecosystem recognizes the influence of both innovation supply and demand on the rate of innovation productivity.

Policy and infrastructure

The push and pull of supply and demand don't occur in a vacuum. They are strongly influenced by public policy and the overall infrastructure for innovation offered by our society. Public policies related to education and training, research funding, regulation, fiscal and monetary tools, intellectual property and market access demonstrably affect our ability to generate innovation inputs and respond to innovation demands. The same can be said of infrastructure – be it transportation, energy, health care, information technology networks or communications. Taken together, the policy and infrastructure environments create a national platform that can accelerate – or impede – the pace and quality of innovation.

More specifically, elements within each of these broad categories interact in dynamic ways. Regulations, for example, can have an important impact on the nature and extent of elements of our infrastructure – from energy, to trade, to telecommunications. Similarly, network infrastructure is crucial for the implementation of key policy goals, in areas ranging from education, to healthcare, to intellectual property. And the growing demand for customization and even personalization of products and services – not only from businesses, but from universities and governments – both affects and is affected

Figure 3: Innovation Ecosystem

by the supply of skills and knowledge. In many ways we are moving from a world in which economic and political advantage depended on economies of scale, to one in which they increasingly derive from what some have called "economies of expertise."[37]

There is much still to be learned about how to define and measure innovation. But even at this early stage, we can see that underlying the reciprocal interactions among the elements of American's dynamic innovation ecosystem – and spanning all its major constituencies, from business, to government, to labor, to academia – there are three foundational requirements:

- The quality of the talent pool
- The society's capacity to take risks, especially for long-term investment
- The continual creation of an infrastructure that anticipates future innovation.

The recommendations of the National Innovation Initiative are a first step toward addressing each of these areas within an overarching plan for national innovation success.

To identify national priorities, NII Working Groups have examined major dimensions and drivers of innovation: skills, finance, infrastructure, the public sector, research frontiers, trade and investment policy, and how innovation is evolving in the 21st century (see www.compete.org for the Working Group reports). The groups have produced more than 80 recommendations that were reviewed and supplemented by a panel of distinguished expert advisors and by the NII Principals. The NII Principals and their Advisory Committee have established three priority focus areas with high-leverage recommendations.

IV

NII GOALS AND RECOMMENDATIONS

America's Innovation Imperative: Where once we optimized our organizations for efficiency and quality, now we must optimize our entire society for innovation.

As a reminder, the recommendations of the National Innovation Initiative are organized into three broad categories:

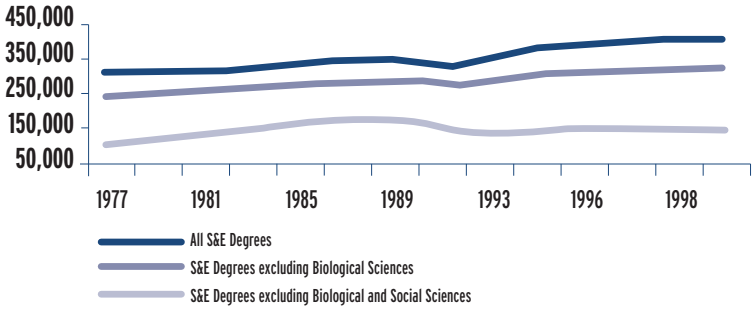
1. Talent: the human dimension of innovation, including knowledge creation, education, training and workforce support.

2. Investment: the financial dimension of innovation, including R&D investment; support for risk-taking and entrepreneurship; and encouragement of long-term innovation strategies.

3. Infrastructure: the physical and policy structures that support innovators, including networks for information, transportation, health care and energy; intellectual property protection; business regulation; and structures for collaboration among innovation stakeholders.

Figure 4

Number of S&E Bachelor's Degrees Earned in the U.S.



1. Talent — The Nation's Key Innovation Asset

America's workers and their families – present and future – are the first priority of the National Innovation Agenda. On an individual level, we must support workers' and families' ability to succeed, not merely survive, in a world in which skills needs are rapidly changing and the competition for jobs is global. At the national level, it's about human creativity and the human capital that drives innovation and economic growth.

The National Innovation Talent Agenda focuses on three priorities:

- Build the base of scientists and engineers
- Catalyze the next generation of innovators
- Empower workers to succeed in the global economy.

Goal No. 1 *Build the Base of Scientists and Engineers*

The Agenda calls for implementing a National Innovation Education Strategy.

Innovation capacity depends, in no small measure, on the cadre of scientists and engineers who generate and deploy ideas. But unless the United States takes swift action, the demand for S&E talent will far outstrip supply. The number of jobs requiring technical training is growing at five times the rate of other occupations. Yet the average age of America's S&E workforce is rising, and the average number of entrants is static or declining, outside of the biological and social sciences.

Many of America's working scientists and engineers are products of the National Defense Education Act (NDEA) of 1958, passed in the wake of Sputnik. The NDEA sparked a half-century of remarkable innovation and wealth creation – and it may help explain why approximately 60 percent of the CEOs of the Fortune 100 have science or engineering degrees.[38] In the knowledge economy, the ability to understand the technological foundations of growth is becoming even more critical to every career path.

However, enrollments are moving in precisely the wrong direction. A quarter of the current science and engineering workforce is more than 50 years old, and many will retire by the end of this decade.[39] New entrants into science and engineering fields are not replacing these retirees in sufficient numbers.

Although K-12 education is not a primary focus of the NII, it is clear that the science and engineering problem begins early in the K-12 pipeline. We are losing our future scientists and engineers around the junior high school years. Less than 15 percent of U.S. students have the prerequisites even to pursue scientific/technical degrees in college.[40] U.S. high school students underperform most of the world on international math and science tests. And most have little interest in pursuing scientific fields. Only 5.5 percent of the 1.1 million high school seniors who took the college entrance exam in 2002 planned to pursue an engineering degree.[41]

Clearly, some of these trends are being felt at the undergraduate level. The number of degrees granted in every field of science and engineering, other than the biological and social sciences, has remained flat or declined since 1985 (see Figure 4).[42] Globally, the United States ranks seventeenth in the proportion of the college-age population earning science and engineering degrees, down from third place several decades ago.[43] The fraction of all 24-year-olds with science or engineering degrees is now higher in many industrialized nations than in the United States. The United Kingdom, South Korea, Germany, Australia, Singapore, Japan and Canada all produce a higher percentage of S&E graduates than the United States.[44]

The nation must take deliberate steps to expand the pool of technical talent. At the undergraduate level, financial incentives matter (especially given escalating tuition costs). The Tech Talent Bill, passed in 2002 by the House and largely incorporated into the 2002 National Science Foundation Authorization Act (PL 107-368), addressed this

Strength through Education: The National Defense Education Act

There is a strong precedent for responding to national challenges – and opportunities – through education.

In October 1957 the successful launch of Sputnik set the stage for lawmakers returning to Washington. Not only was Sputnik the world's first satellite, but it was also the first intercontinental ballistic missile. In dramatic fashion, the Soviets appeared to be ahead in the space race and the Cold War.

In response, the U.S. federal government launched an effort to nurture the sciences and develop new technologies.

The first and most transformational piece of legislation was the National Defense Education Act, signed by President Eisenhower on September 2, 1958. This act, along with the establishment of NASA a month later, laid the groundwork for the modern era of federal support for basic research, and for invigorating the nation's R&D investment.

Driven by the NDEA, federal expenditures for education more than doubled. In higher education, this included funding for federal student loan programs, graduate fellowships in the sciences and engineering, institutional aid for teacher education, funding for capital construction and a surge of funds for curriculum development in the sciences, math and foreign languages.

Through this new investment, the U.S. fundamentally changed both the level and locus of research and development. Research funding soared, and research universities became active contributors to a system that had been dominated by defense agencies. We also sent the first man to the moon.

Source: Center for Studies in Higher Education, University of California, Berkeley http://ishi.lib.berkeley.edu/cshe/ndea/

issue by creating a class of incentives for universities to increase the fraction of students receiving undergraduate degrees in science and engineering. However, these NSF-directed programs have not been funded as authorized, so their potential impact remains unrealized.

Incentives also matter in reaching out to underserved and underrepresented students. African Americans, Hispanics and other ethnic and racial minorities account for only 6 percent of the science and engineering workforce – a figure far below their demographic presence.[45] Women represent only a quarter of the science and engineering workforce, even though they make up nearly half of the total U.S. workforce. By 2020, more than 40 percent of college-age students will be ethnically and racially diverse.[46] If America is to strengthen its base of science and engineering talent, it must act to recruit the fastest growing segments of the workforce.

The availability of scholarship money is a critical factor in the choice of majors. The NII proposes to engage the private sector, which is a major consumer of technical talent. The recommended "Invest in the Future" scholarship fund would create tax incentives for corporate and individual donors who support the next generation of innovators. The goal would be to provide a scholarship to any qualified student majoring in math or science at a four-year college who has an economic need and who maintains a high level of academic achievement.

At the graduate level, three approaches promise to expand the supply and diversity of the S&E pool. The first is to adopt portable graduate fellowships. Thirty years ago, graduate student stipends were funded separately from research. Today, however, the typical graduate student must secure a research position in a funded project to qualify for a stipend – and that financial incentive, rather than any demand mechanism, largely determines the choice of field and specialization. Portable graduate fellowships awarded competitively and based on merit would give control of educational choices back to students – increasing their ability to respond to emerging fields and market demands – and encourage more students to pursue science and engineering paths.

SMART Scholarships for National Security

Congress has responded to the growing deficiency in the right mix of scientists and engineers to support our national security workforce needs. It recently passed legislation authorizing $2.5 million in fiscal year 2005 in support of a Science, Mathematics and Research for Transformation (SMART) Defense Scholarship Pilot Program to begin to address this critical issue.

SMART requires supported recipients to be U.S. citizens who must pay back their support through employment at a defense laboratory. The Department of Defense is building on this authorization by proposing an enhanced program for fiscal year 2006 called SMART – National Defense Education Act.

To complement these fellowships, establishing traineeship grants to institutions will encourage competition for talented students by creating more varied educational choices. Traineeships would focus on frontier research areas and multidisciplinary or innovation-oriented studies, and include exposure to academic, industry and government laboratories.

Third, the recently created Professional Science Masters (PSM) programs represent another promising approach that melds the worlds of science and business, recognizing that productive careers for science students are not limited to research laboratories or classrooms. The PSM creates the first graduate degree in the sciences and mathematics that extends science training into strategic planning and business management, as well as government regulation. The programs focus on multidisciplinary specialties such as business and IT, biology and IT (bioinformatics) and chemistry and IT (computational chemistry). The PSM attracts the same relatively high proportion of women and historically underrepresented minority students as do other master's degree programs in science. The challenge is that these programs and students fall outside traditional graduate school funding mechanisms and lack an established base of support.[47]

Beyond strengthening the domestic S&E pool, we need to continue to attract the best and brightest from around the world. Few would disagree that foreign scientists make critical contributions to the nation's scientific and technical talent – as students, as faculty and in business. Foreign students account for nearly half of all graduate enrollments in engineering and computer science.[48] Foreign scientists comprise more than 35 percent of engineering and computer science university faculties and nearly a third of the S&E workforce.[49]

There are indications, however, that post-9/11 visa policies are reversing decades of openness to foreign scientific excellence. Delays and difficulties in obtaining visas to the United States are contributing to a declining in-flow of scientific talent. And other countries can and do take advantage of our increasingly cumbersome visa process. With the strengthening of foreign science, there are many attractive scientific opportunities abroad to substitute for U.S. conferences, degrees and visiting scholar positions. No one disputes the need for safeguards and assessment of foreign entrants. However, a system that is transparent and efficient and also offers fresh incentives for the best and brightest can offset current obstacles.

Recommendations

- Create an "Investing for the Future Fund" – a national S&E scholarship fund that provides tax credits to companies or individuals who contribute scholarship funds.
- Fully fund the commitment to expand incentives for S&E education as authorized in the 2002 NSF Authorization Bill.
- Create a competitive, merit-based, next-generation fellowship program consisting of at least 5,000 portable graduate fellowships for up to five years, at a stipend level comparable to the NSF Graduate Research Fellowship Program.
- Establish new traineeship grants to institutions for terminal degree programs that provide unique and creative academic settings involving multidisciplinary studies, innovation-oriented studies and exposure to academic, industry or government laboratories and research.
- Direct NSF to fund PSM programs at institutions that demonstrate innovative approaches to orienting master's level degree programs towards scientific or technical skills needed in the U.S. workforce. Institutions would be required to provide matching funds to receive awards.
- Establish an expedited immigration process, including automatic work permits and residency status for foreign students who: a) hold graduate degrees in science and engineering from American universities, b) have been offered jobs by U.S.-based employers and who have passed security screening tests.

Best and Brightest around the World: Critical for U.S. Innovation

America is country of immigrants, and nowhere is that more apparent than in the realm of science and innovation. Teaching and research at U.S. universities depend on a steady stream of foreign scientists and engineers. According to a 1998 National Research Council Report, about a third of U.S. winners of the Nobel Prize were born outside of the United States.

Recent immigrants also play an important role in entrepreneurship. The Public Policy Institute of California found that Chinese- and Indian-born entrepreneurs head 29 percent of Silicon Valley start-ups (up from 13 percent in the mid-1980s).

However, post-9/11 immigration policies are having an impact on the ability of foreign students and scientists to study, visit or work in the United States. The number of foreign students on American campuses declined last year (2003-2004) by 2.4 percent – the first drop in foreign enrollments since the 1971-1972 academic year, according to the Institute for International Education. And recent evidence indicates that the decline in foreign enrollments is continuing in 2004-2005. A survey of major graduate institutions conducted by the Council of Graduate Schools has found a 6 percent decline in new foreign enrollments in fall 2004 – the third year in a row with a substantial drop. While this decline is less sharp than in last spring and fall, reversing such declines is difficult. As Victor Johnson of Nafsa: Association of International Educators notes, "Perceptions abroad are lagging behind reality…The word is out on the street in China: You can't get a visa to study in the United States."

Source: *The Chronicle of Higher Education*.

Goal No. 2 *Catalyze the Next Generation of American Innovators*

An innovation economy that drives economic growth and job creation will be fueled by new ideas – and those will start from curiosity-based research, then move to application and finally to commercial exploitation. America must certainly retain and enhance its research at the frontiers. But it must also improve the processes that evolve these ideas into new products, new services or new solutions to pressing societal problems.

Universities have always protected and encouraged inspired individuals to expand and share humankind's basic scientific knowledge base. Their ideas represent some of our strongest national assets, and we must safeguard the mechanisms that fund and promote them. However, universities are also key to creating a new generation of skilled workers, women and men who are ready to use their knowledge of the latest technologies to create better services, products and solutions.

All Americans will need a variety of tools to be successful. People are not born with inherent innovation skills, but they can learn them. They can acquire the social skills to work in diverse, multidisciplinary teams, and learn adaptability and leadership. They can develop communication skills to describe their innovations. They can learn to be comfortable with ambiguity, to recognize new patterns within disparate data, and to be inquisitive and analytical. They can learn to translate challenges into opportunities and understand how to complete solutions from a range of resources.

These skills are best acquired by experiencing innovation first-hand, building the confidence that underpins future success. To quote Benjamin Franklin: "You tell me, I forget; you teach me, I remember; you involve me, I learn."

If our nation is to lead in innovation, our universities will need both to be adept at cross-disciplinary research and education and to rethink how they are organized to inform faculty and students about the process of commercialization. Commercialization is a complicated issue within universities. Care must be taken to preserve the integrity of unbiased research and access to open intellectual inquiry and publication. However, commercialization done properly is ultimately of great benefit to the public and to learning itself.

The question is whether universities have the internal structures and investments in place to support faculty and students interested in taking ideas into the commercial realm and to help produce graduates who can lead this type of activity. The Bayh-Dole Act gives universities a generous opportunity to create commercial outputs from federally funded basic research and to benefit from this financially. Universities' record in taking advantage of this and other incentives – though improving – has been uneven. We need a fundamental shift in philosophy in academia that embraces the traditional role of creating new knowledge but acknowledges the responsibility to inform and promote an innovation mindset, particularly among scientists and engineering faculty and students.[50]

Successful models exist in several areas of the country. They include such activities as creating venture laboratories and incubators; developing curricula that are multidisciplinary and include real-world interaction with industry; establishing workshops and seminars that help students and faculty understand the mechanics of commercial development; supporting internships with local startups and small businesses; funding multidisciplinary chairs that focus on both technical and business topics; setting up internal resources (e.g., commercial advice and assistance); and creating a general campus culture that applauds innovation.

These kinds of tools and resources not only inform and educate potential innovators. They can also help spark ideas by encouraging those with different technical skills to enter into active discourse about ideas and problems. A new generation of innovators must learn that they operate in a larger world. It is important not only to understand that world, but also to communicate effectively within it.

Creating New Kinds of Innovation Professionals

A transformative development in modern work is the growth of distributed, robust organizations – highly flexible groups that operate collaboratively across distance and time.

University of Michigan faculty in the School of Information's Collaboratory for Research on Electronic Work (CREW) are training a new kind of professional to operate in this new work environment.

CREW develops *collaboratories* – partnering with Lucent, Steelcase, IBM and academic, scientific and not-for-profit organizations, as well as many others – to carry out a variety of projects. They include: distributed product development in software engineering; geographically distributed auto parts design; the use of audio and video in distance collaboration; upper-atmospheric and space sciences; cancer, AIDS and bioterrorism research, bioterrorism, service provision by non-profit organizations; and more.

The Committee for the Study of Invention, sponsored by the Lemelson-MIT Program and the National Science Foundation, puts it this way:

To advance their endeavors, inventors commonly need a range of other skills concerned with relating to the constituencies around them. Although inventors focus on invention most centrally, they often must play other roles as well. They need the mindset and skills to promote, persuade, market, marshal financial resources and so on…They often need to function as "intrapreneurs" to advance their missions within an organization.[51]

In addition, universities, colleges and community colleges must better synchronize their educational resources with local business enterprises. This would integrate these assets into teaching, help business learn how to manage more effectively for innovation, and enable employees to improve their skills. That kind of creative curriculum will be critical to creating innovation synergies.

American universities also can train a new generation of economists in innovation theory and lead the way in developing metrics to understand and manage innovation. Strengthening these disciplines would improve both national policymaking and decisions by companies.

Recommendations

- Universities should promote an innovation-oriented culture while maintaining a commitment to creating new knowledge at the frontiers of research. This culture should seed traditional technical studies with new exposure to methods for creative thinking and translating ideas into commercial applications. Tenure and promotion policies should give weight to teaching creativity, inventiveness and innovation. These changes may require reassessments of organizational structures and learning environments.
- Academic institutions should develop curricula specifically designed to teach innovation skills and support major changes in innovation learning. They should expand the use of experiential learning.
- Innovation Partnerships need to be created to bridge the traditional gap that has existed between the long-term discovery process and commercialization. These new partnerships would involve academia, business and government, and they would be tailored to capture regional interests and economic clusters.
- States and universities should fund internships for innovation-oriented students interested in experiencing local startup and small business environments.
- Universities and colleges – including community colleges – should establish curricula to teach innovation management skills to middle and senior managers from small businesses. States should create local and regional innovation synergies by providing incentives for interaction between small business and educational institutions and resources.
- The National Science Foundation should take a significant role in funding pilot efforts to create innovation-oriented learning environments in K-12 and higher education. It should also sponsor research into the processes involved in teaching creativity, inventiveness and commercialization in technical environments.

Goal No. 3 *Empower Workers to Succeed in the Global Economy*

America must help workers and their families navigate the challenges of today's innovation economy. Those challenges include more rapid technological change, faster product cycles, a shorter "half-life" for many technical skills (see Figure 5) and more intense global competition. This will require a new relationship among employees, businesses, universities and government that:

From the Lab to the Market

To help their research scientists get ideas out of the lab and into the marketplace, many colleges and universities are developing active support systems to nurture their "next generation innovators" – helping faculty to identify inventions with commercial potential and shepherding them to commercial market.

For example, Georgia Tech's Advanced Technology Development Center provides Tech faculty with commercialization grants to develop prototype products – while its VentureLab provides a one-stop center to guide faculty inventions through the commercialization process.

- Stimulates workforce flexibility and skills through lifelong learning;
- Accelerates portability of healthcare and pension benefits;
- Aligns skill needs more tightly to training resources; and
- Expands assistance to those dislocated by technology and trade.

Although advances in technology have historically made America stronger, more prosperous, more productive and healthier, those advances have also created hardships for workers whose skills are tied to older technology or outmoded techniques. History offers many examples. Consider agricultural productivity: In 1900, it took nearly 40 of every 100 Americans to feed the country. It now requires just three.[52] Consumers enjoy far more food choices at lower cost, but the transition from farm employment to new kinds of work was difficult for many families and rural communities. Similarly, the railroad industry laid off hundreds of thousands of people as new transportation options dawned, but the automotive industry created millions of new jobs.

Competition, domestic or global, is also a positive force, but it, too, poses challenges. Competition lowers prices, improves quality and service, and encourages innovation. But competition also increases pressure on workers and firms to learn new skills and explore new kinds of work. It means that some workers will suffer hardship through lost wages or jobs – and some firms will fail, even as the economy creates new jobs and new firms rise.

The United States has built a safety net to help workers through transitions. The question is whether this framework offers adequate support for Americans to thrive in an increasingly competitive global innovation economy, in which new skills are in demand and are shifting more rapidly.

We cannot turn back the clock on technology, nor begrudge other nations' drive to compete and improve living standards. We can, however, make choices about how to help those affected in the United States by job and business churn. The National Innovation Initiative urges improving training and lifelong education opportunities to help U.S. workers prepare for and adapt to changes in technology or competition that adversely affect them.

Incentives for Lifelong Learning

Establishing a national policy of voluntary individual asset accounts to finance education and training is vital today to help workers cope with the churn of transition. Within the decade, training incentives will also be critical to the nation's ability to sustain its innovation economy. The impending retirement of the Baby Boomers means that nearly seven million people who currently hold key managerial, professional and technical jobs could retire over the next ten years.[53]

Lifelong learning accounts would enable workers continually to upgrade their skills, both to meet the changing needs of business and industry and to help advance their own careers and earning potential. Accounts would allow individuals to enroll in accredited training programs operated by public, private and union-based institutions. Ideally, these would be integrated into the existing structure of retirement or educational accounts.

Recommendation

Create Lifelong Learning Accounts for employees that allow:

1. Tax exempt contributions by workers
2. Tax credits for employer contributions

Portability of Benefits

In a world of ever-more rapid change, workers need a genuinely portable safety net. Portability of pensions is increasing, with the

Figure 5

Skill Sets Have Shorter "Shelf-Lives" –

IT Skills Shift from "Hot" to "Cold" at a Quick Pace

2000–2001 Skill Shift

2001 Rank	2000 Rank	Skill	Movement
1	3	Unix	▲
2	2	C++	No change
3	1	Java	▼
4	5	SQL	▲
5	6	Visual Basic	▲
6	4	HTML	▼
7	12	C Language	▲
8	8	Oracle 8/8i	No change
9	7	SQL Server	▼
10	10	Microsoft ASP	No change
11	9	Windows NT4	▼
12	n/a	TCP/IP	NEW

2001–2002 Skill Shift

2002 Rank	2001 Rank	Skill	Movement
1	n/a	Unix/Tornado Development	NEW
2	1	Unix	▼
3	3	Java	No change
4	n/a	COM (Microsoft)	NEW
5	4	SQL	▼
6	n/a	Development Life Cycle for Software	NEW
7	n/a	Develop Design Specs	NEW
8	n/a	Dev. Programming Code to Spec.	NEW
9	n/a	Dev. SW Architecture	NEW
10	n/a	Dev. Methodology and Procedures	NEW
11	n/a	Project Leadership	NEW
12	2	C++	▼

public sector supporting tax-favored retirement vehicles such as the popular 401(k) plans. Social Security also is a basic portable pension system. Industry has made progress with the shift from traditional defined-benefit plans to cash-balance plans and defined-contribution plans, but there remains more to do to ensure widespread employee participation and effective savings and investment practices.

Healthcare benefits remain far less portable and are often blamed for employees' unwillingness to change jobs, due to the risk of losing coverage. A survey sponsored by the Kaiser Family Foundation found that about one in six people with health insurance are very worried about losing their coverage. One in eight people stay in their current job because they fear they will lose health coverage if they change.[54]

Uneven incentives for workers and company spending on health coverage, along with rapidly escalating health costs, add to the difficulties facing healthcare benefit portability. These conditions create a drag on the incentive and financial capacity of employers to find the best match for knowledge and skills. Healthcare savings accounts offer one means of providing portability, but additional options are needed that reach a broader audience.

Recommendations

- Employers should automatically enroll employees into 401(k) plans to increase participation rates in retirement saving.
- Employers should design defined-contribution plans to provide an annuity option on retirement, rather than a lump-sum payout. The annuity option will encourage more responsible financial arrangements for retirement.
- States should clarify regulations affecting annuities and offer tax incentives to employees and employers to make annuity options more attractive.
- States and the federal government should help employees understand that they may receive financial advice and education through their workplace to improve their investment choices, with protections for employers who provide the channel for this advice.
- The federal government should create legal certainty for cash-balance pension plans, to ensure that employers can continue to offer them. These plans are popular with many employees and have significant advantages over many defined-contribution plans.
- States and the federal government should encourage the widespread availability of Health Savings Accounts, including affordable options for low-income workers, as a health insurance option that provides portability for employees.
- States and the federal government should define a role for government re-insurance of higher-cost healthcare expenses, so as to reduce the cost of employer-provided coverage and reduce the cost of healthcare to employees.

Worker Training and Transition Assistance

Important parts of the American workforce remain underserved by existing training and transition programs. Professions that in the past were little exposed to international competition now compete against skilled workers overseas connected through modern communications networks. Technological advances also contribute to job turnover, and many people reentering the workforce today are beginning new jobs rather than returning to their old positions.

So although the rate of U.S. unemployment remains fairly low by historic standards or compared to many developed economies, we see new populations of Americans feeling the brunt of global competition, demand for new skill sets, and, for some workers, lower wages than in their previous jobs. America requires a contemporary workforce assistance system that addresses these realities.

"Over the next ten years, 26 of the top 30 fastest growing jobs will require some post-secondary education or training…The demand for skilled workers is outpacing supply, resulting in attractive, high-paying jobs going unfilled."

—Emily Stover DeRocco, Assistant Secretary of Labor for Employment and Training

Important reforms are underway. The Labor Department has launched an initiative to leverage federal and state funds for job training in high-growth industries like healthcare, information technology services, biotechnology and high-tech manufacturing. The Department also seeks more flexibility for state and local governments to partner with local firms and academic institutions to teach skills needed locally.

The NII supports these goals and more. The Trade Adjustment Assistance (TAA) Program, for example, offers income support, training resources, health benefits and relocation assistance, in addition to benefits available under the Unemployment Insurance system and other programs governed by the Workforce Investment Act. TAA benefits, however, are limited to manufacturing employees who are displaced as a result of imports. They don't extend to services jobs, which constitute nearly 70 percent of U.S. employment and are increasingly subject to global competition.[55] TAA also is unavailable for workers displaced by investment decisions such as plant relocations.

The bottom line: We should ensure that every worker can obtain the education, training and skills needed to succeed in the 21st Century.

Recommendations

- Reform and rename the Trade Adjustment Assistance Program to cover workers displaced for reasons other than trade, including service sector workers.
- Offer more flexibility and focus under federal-state employment and training programs. States and the federal government should have more discretion to devote employment and training resources toward high-performance programs, high-growth skills and skills in demand by local firms.
- Expand temporary wage supplements that help move workers more quickly off unemployment insurance and into new jobs and on-the-job training. The Alternative Trade Adjustment for Older Workers Program should be expanded to include younger workers and should not be linked exclusively to trade dislocation.
- Re-institute H1-B training grants to ensure that Americans are trained in the skills and fields for which companies now bring in foreign nationals.
- Companies should strive to develop innovation-enhancing cultures and offer programs that encourage innovation, including certifications, collaborative environments, interdisciplinary incentives and commercialization skills.

2. Investment—Reinforcing Risk and Rewards

In the Industrial Age, machines and physical plant were king – the core assets of most companies. In an innovation economy, however, intellectual capital is the engine that drives economic growth and prosperity. Investment risks and rewards are increasingly built around ideas – how we develop and deploy them, how we protect them and how we value them.

The National Innovation Investment Agenda focuses on three priorities:

- Revitalize frontier and multidisciplinary research
- Energize the entrepreneurial economy
- Reinforce risk-taking and long-term investment.

Goal No. 1 *Revitalize Frontier and Multidisciplinary Research*

Investment in frontier research has always been the bedrock of American innovation. Many of the country's most innovative industries were built on decades of research that had no discernible applications. No one dreamed in the 1940s that the esoteric field of quantum mechanics would spawn the semiconductor and IT revolutions. Engineers working on time-sharing techniques probably never anticipated the Worldwide Web and e-commerce. Scientists researching atomic motion likely didn't anticipate or predict global positioning devices.

The NII has identified several emerging problems in the research base.

Shifts in funding from bold, transformational discovery to incremental research

Public funding for research has kept America at the frontiers of discovery, creativity and research breakthroughs. The long time-frames, inherent risks and inability to capture returns on investment make discovery research inherently a governmental function. But publicly funded research has been steadily moving away from the frontiers of knowledge and closer to application and development. The federal research investment has grown conservative – increasingly driven by consensus, precedent and incremental approaches. At this time of global opportunity and challenge, what is needed is a return to the basics – a forward-looking vision that drives the nation's research investment across uncertain terrain toward new knowledge and breakthrough innovation.

Ironically, one of the milestone moments for America's discovery research was the end of the Cold War. The loss of urgency affected both the quantity of funding for breakthrough research and the cutting-edge quality of the public investment. Out of investments by the Department of Defense had come nuclear technologies, spy satellites, precision-guided munitions, stealth materials and advanced radar – technologies that helped to win the Cold War. But so, too, did microelectronics, weather and communications satellites, global positioning satellites, passenger jets, supercomputing, the Internet, robotics, sensor technologies, composite materials and magnetic resonance imaging – all of which have had profound economic impact.

Lack of investment in multidisciplinary research

Along with a renewed focus on the frontiers of discovery, we need a new focus on knowledge integration, communication and collaboration. Because innovation is occurring at the intersections of knowledge, next-generation innovation will depend upon the cross-fertilization and fusion of research within and across the biological and physical sciences, the spectrum of engineering disciplines and entirely new fields of scientific exploration. This will require that a higher percentage of research funding be allocated to the interconnections among disciplines – and to the infrastructure that supports multidisciplinary research.

Nowhere is the need for new multidisciplinary approaches clearer than in the area of emerging "services science" – the melding together of the more established fields of computer science, operations research, industrial engineering, mathematics, management sciences, decision sciences, social sciences and legal sciences that may transform entire enterprises and drive innovation at the intersection of business and technology expertise.

Services science can begin to address major questions at the heart of 21st century innovation: How do organizations continue to recreate themselves? How do they manage technological innovation? Can we simulate the most complex behavioral systems? Developing the intellectual basis for solving problems in business process design and organization, and providing an analytic basis for decision-making and leadership have the potential to spur entirely new innovation frontiers.

Underinvestment in the physical sciences and engineering

Scientific advancement has blurred the lines between scientific disciplines, so that advancement in one area is furthered by development in others. For example, future products in life sciences are very likely to result from a combination of modern biology, nanotechnology, information sciences and the physical sciences and engineering. Over the past 50 years, the United States has significantly increased investment in life sciences R&D, with remarkable results. Unfortunately, the rate of increase in R&D has not been equally robust in other disciplines. Although federal funding for the life sciences has increased four-fold since the 1980s, growth in the physical sciences, engineering and mathematics has been stagnant in constant dollars.

We urge an increase in R&D investment across the disciplines. Because scientific advancement is interdependent, R&D investments must not be a zero-sum game that shifts investment from one area to others, but rather a comprehensive initiative that brings investment in other disciplines up to the level at which life sciences has thrived.

While public funding creates the anchor for the nation's research investment, more effective incentives to stimulate private-sector research investment are equally critical. Nearly two decades of studies have demonstrated that the R&E tax credit creates incentives for increased industrial investment in R&D (approximately one dollar of additional private R&D in the short run and about two dollars in the long-run), generates more tax revenue than the government spends and has a net positive impact on productivity and economic growth. The NII Investment Agenda supports the need to: 1) make the R&E credit predictable and permanent, 2) restructure the credit so that companies can realize its full benefits and 3) extend the credit to research partnerships and consortia to encourage cross-sector and multidisciplinary research.

Recommendations

- Spur radical innovation by reallocating three percent of all federal agency R&D budgets toward "Innovation Acceleration" grants that invest in novel, high-risk and exploratory research.
- Affirm the goal set in the Quadrennial Defense Review (2001) and by the Defense Science Board that at least three percent of the total Department of Defense budget be allocated for defense science and technology. Within this amount, the Department of Defense's historic commitment to fundamental knowledge creation should be restored by directing at least 20 percent of the total Department of Defense science and technology budget to long-term, basic (6.1) research performed at the nation's universities and national laboratories.
- Increase significantly the research budgets of agencies that support basic research in the physical sciences and engineering, and complete the commitment to double the NSF budget. These increases should strive to ensure that the federal commitment of research to all federal agencies totals one percent of U.S. GDP.

Innovation Hot Spot—Rochester, NY and Optics

Infotonics Technology Center, Inc., located near Rochester, NY is a model innovation hot spot. It has both a geographic and industry focus and was formed as a result of collaboration among private, public and university stakeholders.

Infotonics is an industry-led Center of Excellence for applied research, development and commercialization of photonics and microsystems. Formed in 2001 by Eastman Kodak Company, Corning, Inc., and Xerox Corporation, the Center is structured as a not-for-profit consortium of industry and universities. This partnership leverages the collective strengths and resources of large and small regional industries, the governments of New York State and the United States, and an array of prominent universities.

The Center accelerates the transition from basic and applied research to commercialization of next-generation optical communication networks and advanced imaging through its support of prototyping engineering and its ability to support pilot-scale fabrication in a clean-room environment.

The explicit goal of the technology center is to reduce the financial risk frequently associated with the development process and to increase the probability of commercial success.

- Allocate an increasing proportion of future research funding at universities to multi-and interdisciplinary research – and to the facilities and research infrastructure to support it.
- Recognize "services science" as a new academic discipline – and encourage universities, community colleges and industry to partner in developing curricula and in training a workforce focused on services and enterprise transformation.
- Enact a permanent, restructured R&E tax credit and extend the credit to research conducted in university-industry consortia

Goal No. 2 *Energize the Entrepreneurial Economy*

By almost any measure, the U.S. entrepreneurial economy leads the world – a critical advantage, since as much as one-third of the difference in economic performance among countries is attributed to the difference in their levels of entrepreneurial activity.[56] Our entrepreneurial engine has clearly helped to power U.S. innovation, productivity and economic growth.

Demonstrably, there is nothing awry with the health of the overall U.S. entrepreneurial system. Indeed, rebounding from the recent economic slowdown, the nation's entrepreneurial economy posted a 12 percent growth rate in 2003.[57] However, we can do better to enable entrepreneurs to take risks and to translate ideas into innovation.

We're still leaving ideas on the table. On average, only one in ten patents is ever commercialized.[58] Thousands of inventions lie dormant in the hands of universities, research centers and private companies. For those ideas that are pursued commercially, only seven out of every 1,000 business plans receive funding.[59]

To pick up the pace, the nation needs to look to its regions. The combustion behind innovation is inherently regional – on the ground where research, business, risk capital and workers come together to turn ideas into products, processes and services. Optimizing for innovation nationally means strengthening the regional capacity for entrepreneurship.

The national innovation investment agenda focuses on three key areas:

- Create regional innovation hot spots
- Coordinate and focus public-sector economic development investment
- Unleash underutilized capital

Create regional innovation hot spots

Some regions such as Silicon Valley, the Pacific Northwest, Route 128/Boston and Greater Austin have been extraordinarily successful in stimulating entrepreneurship. Yet their innovation assets – idea generation, skilled managers and available capital – are not unique. They have been especially successful in building the interconnections that link intellectual, financial and human capital.

Innovation hot spots create institutions that foster knowledge transfer, collaboration and support for start-ups. Hot spots combine and accelerate the deployment of key elements of the innovation ecosystem by:

- building on cutting-edge, multidisciplinary research
- providing the training ground for next-generation innovators
- creating a crossroads between researchers and businesses
- linking innovators with early-stage funding, both public and private, and with experienced innovation mentors

Technology Incubators – Driving Regional Innovation

Technology incubators and research parks are tools many universities use to diversify regional economies, create jobs and contribute to local prosperity.

Rensselaer Polytechnic Institute's (RPI) Technology Park and incubator program – the first in the United States – are examples of how universities, local businesses and workers come together to innovate, invent, and commercialize groundbreaking ideas. Among success stories at RPI:

- Mapinfo, a publicly-traded company with 700 employees and revenues in excess of $100 million, is headquartered in the Rensselaer Technology Park. The company evolved from a business plan written by three undergraduate students with an idea to integrate data and mapping for navigation;
- Vicarious Visions, a software company in the tech park, which was launched by a Rensselaer undergraduate student and his brother to create high-end software for the entertainment industry.

Since its creation in 1980, the Rensselaer incubator program has served 180 tenant companies that have created more than 2,000 jobs. The survival rate for incubator companies is 80 percent. Annual sales of incubator graduate companies exceed $500 million. At the present time, the Rensselaer Technology Park houses 54 companies with more than 2,400 employees.

- creating a focal point for local innovation communities to foster networks that would facilitate the transfer and commercialization of new ideas.
- developing links to regional economic development initiatives
- raising the visibility of innovation in the region with policy makers and the public.

The concept is not new, but neither has it emerged as part of a coordinated national strategy for innovation. The U.S. Department of Commerce's Economic Development Administration (EDA) funds a number of EDA University Centers designed to promote linkages among higher education institutions and local economic development and business organizations. New York and California have created centers of excellence that combine public and private funding for emerging technology areas. In the Greater Rochester, NY, area, leading private-sector firms and higher education institutions, along with national, state and local funders, have created the Infotonics Technology Center, an institution that supports applied research in local IT and optics firms. The Larta Institute, in Southern California, is a non-profit organization that serves as a regional hub for technology transfer and as an active economic development intermediary. Incubators and accelerators dot the national landscape.

These are promising but partial efforts. What is needed is a more proactive approach that focuses federal and state, public and private funding on building regional anchors throughout the national innovation economy.

The National Innovation Hot Spot program would create public-private partnerships explicitly focused on supporting regional innovation. In order to ensure the most successful development of these centers, the initial program would solicit applications from across the country to serve as pilot regions. Institutional diversity should be strongly encouraged – locating hot spots at universities, research centers, national laboratories or other non-profit organizations based on geographical diversity and the availability of matching funding by private investors, states and regions.

Coordinate and focus public-sector economic development investment around innovation-based growth

With approximately $20 billion in economic development assistance, the federal government has tremendous financial leverage. But funding for economic development is fragmented across multiple agencies and lacks a consistent innovation focus. To accelerate the link to innovation-based economic growth, the federal government should coordinate its funding through a lead agency process, in which a single agency or department (e.g., the Department of Commerce) is tasked with oversight. Further, economic development funding should flow towards projects in which the private sector, local government and state government present a coordinated plan and provide significant funding. To further reinforce regional collaboration, the Economic Development Administration and other federal agencies involved in economic development should institute regional boundaries that follow metropolitan statistical area (MSA) lines, not state borders.[60]

Accounting for more than 85 percent of federal financial support and more than 20 percent of funding for early-stage development from all sources, the Small Business Innovation Research (SBIR) program is arguably one of the nation's most targeted investments in breakthrough innovation.[61] To build on the program's success, some small adjustments should be made to reflect current market needs. The SBIR program should have the flexibility to fund ideas that can get to the market quickly and to fund some longer-term, complex projects as well. To do this, the Small Business Administration (SBA) should consider allowing venture capitalist-backed companies to receive funding, and to raise the upper limits on its Phase I and Phase II awards.

Like the federal government, state governments have an important role in supporting innovation. At the most fundamental level, states

Community Colleges Meet Local Skills Needs

Using a multi-technology approach, Washtenaw Community College (WCC) in Michigan has created a series of on-demand courses that allow students to leverage technology, take classes on their own schedule and gain relevant skills for local needs.

Students sign up for classes on-line and then receive "the box," a course packet of DVD lectures and custom-designed learning materials. Interacting with professors via email and interactive television, participants complete fully accredited course work.

For example, WCC has used the College on Demand™ model as part of its partnership with the United Association, a plumbers and pipefitters union, to offer courses on construction supervision. WCC also has worked with UA to offer a complete curriculum designed to provide journeymen certification in plumbing and pipefitting supervision.

must tailor strategies to specific regions. A one-size-fits-all development strategy does not work since regions have vastly different economic assets and distinct growth opportunities. States should support regional collaboration by encouraging, not hindering, cross-state collaboration for metro areas that extend across state lines.

In the context of regional economic development, all states should follow the example of leaders like North Carolina and Massachusetts, which have embraced the regional cluster concept. States, through their investments in education, infrastructure and economic development programs, can help refocus priorities on building a strong innovation platform for all of their regions.

Unleash underutilized capital

While many entrepreneurs complain about the "lack of capital," the reality is that most regions do not lack investment capital. They do, however, lack risk capital (see Figure 6). While significant financial assets exist in the hands of firms, individuals and foundations, regions often lack the institutional and informal mechanisms to direct existing capital assets to entrepreneurial activities. To address this need, angel networks and local charitable foundations should become part of every region's innovation strategy.

Wealthy individual investors tend to invest in traditional vehicles like blue chip stocks or real estate. With little access to information or experience with entrepreneurial investment, they have little incentive to explore regional risk investments. Some state and community economic development organizations have addressed this challenge by developing angel networks of qualified investors, who share risk and expertise. These efforts could be strengthened and expanded by supporting a tax credit for early-stage investments by angel funds in qualified, start-up investments.

Similarly, charitable foundations could play a larger role in innovation-based economic development. There are close to 65,000 grant-making foundations spread throughout the country. According to the Foundation Center, these foundations grant more than $30 billion annually to support a wide range of social, cultural and educational causes.[62]

While economic development has been one of the areas of funding, it has not traditionally been one of the leading recipients, nor have donations been aggregated as part of a regional strategy. In Northeast Ohio, foundations from a 13 county area are trying a new model. Led by the Cleveland Foundation, more than 60 regional foundations have jointly pledged to fund economic development efforts aimed at promoting innovation-based growth.

In addition, Northeast Ohio foundations are considering the possibility of investing part of their asset base in local private equity deals. Nationally, this idea could have a major impact on funding availability. An investment of only one percent of the total asset base of all national foundations would represent an additional $4.35 billion in available risk capital.[63]

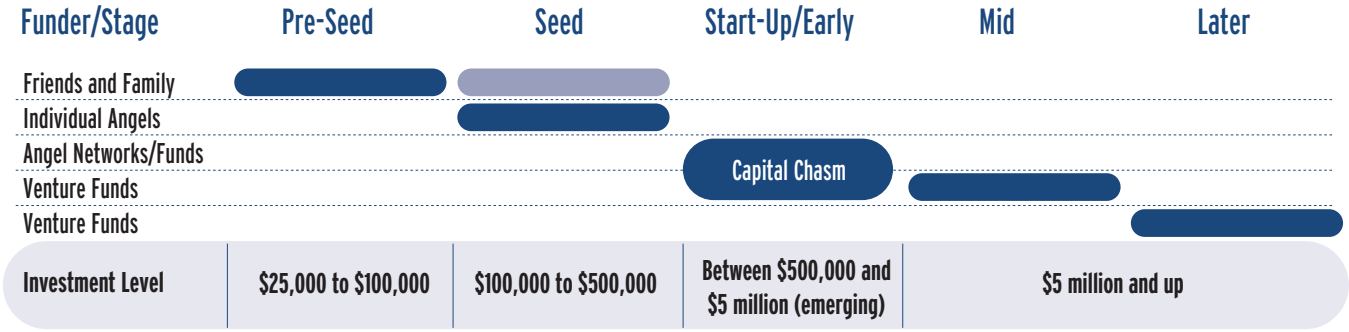
Foundations are already able to invest directly in venture capital funds and start-up ventures as part of their asset portfolio strategy. In addition, foundations may make equity investments in new ventures as part of their payout obligation,[64] so long as financial gains are not the primary goal and the investments further the public good. Thus, foundations can invest in non-profit organizations that support local entrepreneurship through investments (like JumpStart in Northeast Ohio and InnovationWorks in Pittsburgh), as well as directly in ventures.

There are two challenges to increasing foundation investment in the entrepreneurial economy. First, federal tax code regulations are complex and somewhat vague on what kinds of investments are allowable. A clear statement of what is acceptable under the IRS jeopardy investment rules is needed.

The second facet of the challenge is simply educating foundations about the potential triple benefit from these investments. With the

Figure 6

Funding Gap in Risk Capital



The traditional funding gap has been between seed and early stage investments at the $500,000 to $2 million range, where individual investors can no longer make investments. Recently, the gap has been widening as VC firms are shifting investments to focus on more mature firms with larger capital needs. Entrepreneurs report difficulty in raising money between $2 million and $5 million.

Angel networks, which aggregate angel investments, provide a solution.

Susan L. Preston, *Angel Investment Groups, Networks, and Funds: A Guidebook to Developing the Right Angel Organization for Your Community*, Kauffman Foundation, p. 4

investment of a small percentage of assets in regional start-ups, foundations can help a local firm, can play a leading role in creating more favorable regional attitudes toward risk investment, and can potentially increase the value of their asset base.

Most U.S. regions have the assets necessary – the ideas, talent and capital – to support their innovators and entrepreneurs. However, the assets are often hidden, underutilized or disconnected. A coordinated federal, state and local strategy centered around innovation hot spots that fully utilizes available regional capital will give U.S. regions a stronger chance of success in the highly competitive, global economy.

Recommendations

- The federal government should create at least ten Innovation Hot Spots over the next five years. State and local economic development entities and educational institutions should raise matching funds and develop proposals to operate these pilot national innovation centers.
- The federal government should establish a lead agency for economic development programs to coordinate regional efforts and ensure that a common focus on innovation-based growth is being implemented
- The federal government should provide a 25 percent tax credit for early stage investments when made through qualified angel funds. The individuals participating in these funds would need to make a minimum investment of $50,000 each year in order to receive the tax credit. Acceptable investments would be restricted to those that meet requirements for revenue size and age of firm.
- The federal government, through the Internal Revenue Service or Treasury Department, should establish clear guidelines in the Internal Revenue Code on the acceptability of investment of foundation assets in start-up ventures.
- Local leaders and national associations should develop a promotional effort to educate local foundations about the beneficial regional impact of asset investments in entrepreneurial ventures.

Goal No. 3 *Reinforce Risk-Taking and Long-Term Investment*

Investing in innovation demands adherence to two fundamental principles: a willingness to accept risk and a willingness to wait for the return on investment. Although America's entrepreneurial economy understands and embraces these principles, the much larger financial mainstream is moving in precisely the opposite direction. Investment time horizons are getting shorter. Long-term innovation strategies remain undervalued. And business executives in publicly held companies now face a regulatory climate that is blurring the line between business risk and legal risk.

The National Innovation investment agenda focuses on three areas of concern:

- A hyperfocus on short-term results
- Undervaluation of intangible assets
- Regulatory deterrents to risk-taking

Hyperfocus on short-term results

The drumbeat pressures of quarterly results are driving business decisions and drowning out long-term management, investment and innovation strategies.

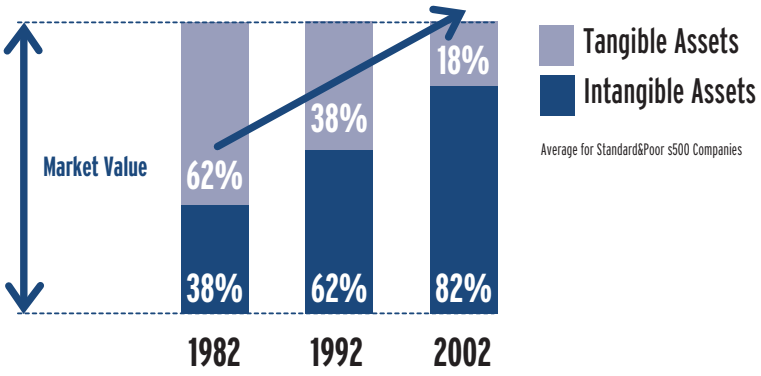
- **Investor patience is in short supply.** The traditional "buy and hold" approach for equity investments is being abandoned by the professionals. U.S. mutual funds hold stocks for an average of ten months, a record low. Annual turnover rates are 118 percent, a record high.[65]

Figure 7

The Growing Importance of Intangible Assets

In the late 1990s, the annual U.S. investment in intangible assets (R&D, business processes and software, brand enhancement, employee training) was roughly $1 trillion, almost equal to the total manufacturing investment in physical assets ($1.1 trillion).

According to some analysts, intangible capital currently constitutes well over half of corporate market value. Accenture, by comparing book value to market values in 2002, approximated that intangible assets accounted for 82% of market valuation.



- **Short investment horizons pressure CEOs to focus on near-term results.** According to surveys by Burson Marsteller, the number one priority for CEOs is shareholder return, followed by industry leadership, customer focus, profitability, best management, best place to work and best talent. The category "Most Innovative" ranks eighth on the list – a priority for only 23 percent of the respondents.[66]

- **The market sees smooth earnings as preferable to long-term value creation.** A survey of financial executives indicates that 78 percent would give up long-term value creation in exchange for smooth earnings. Fifty-five percent would avoid long-term investments that might result in falling short of the current quarterly targets.[67]

- **CEO compensation packages are not geared to long-term value creation.** Over the decade from 1990 to 2001, the share of equity-based compensation in total CEO compensation – how much was coming from options and other forms of equity – grew from 8 percent to 66 percent.[68] But many contend that, far from aligning shareholder and management interests, the shift to equity reinforced the tendency to manage to Wall Street's expectations, rather than long-term value creation.

It is difficult to change Wall Street attitudes. But certainly, short-term pressures on performance could be offset on the one hand, by incentive structures that encourage longer-term value creation by management, and on the other, by performance metrics that reward such investments.

Undervaluation of investment in intangibles

Alan Greenspan notes that over time, and particularly in the last two decades, an increasing share of GDP has reflected the value of ideas more than material substance or manual labor. By the late 1990s, the annual U.S. investment in intangible assets reached roughly $1 trillion, nearly equal to the investment in physical assets (see Figure 7).[69] But this investment is not captured either in the financial accounts of U.S. companies or the national income and product accounts. In essence, we are running today's knowledge economy with measurement tools inherited from 19th century industrialism.

Professor Robert Jenson of Trinity University puts it another way. When navigating risky waters, ships' navigators look not at the tip of the iceberg but at the giant mass that lies beneath. He notes that:

If we make an analogy that the financial statements contain only what appears above the surface, over 99 percent of the accounting theory disputes have centered on the top of the icebergs. We endlessly debate how to value what is seen above the surface and provide investors virtually nothing about the really big stuff beneath the surface...

What lies beneath the surface of the financial reporting icebergs is the giant portion of the bulk of value that lies in intangibles such as R&D, intellectual property, business processes and software, brand enhancements, human resources and training programs, and strategic alliances.[70]

In a recent Deloitte and Touche survey of corporate board members and senior managers, more than 90 percent agree that financial indicators alone cannot capture their companies' strengths and weaknesses. But only a third said their companies were excellent or good at measuring and monitoring non-financial performance, while nearly a quarter rated themselves as fair or poor. Nearly half said that their company's non-financial metrics were ineffective or highly ineffective in helping the Board and CEO make long-term decisions. The two primary reasons given were the lack of measurement tools and the difficulty in understanding the bottom-line impact of intangible assets.[71]

As we move deeper into an era of innovation-based growth, other advanced economies are moving rapidly to understand and implement systems that value investments in intangibles, an area in which

Figure 8

Marketplace Recognizes Value of Intangibles

Company	2004 Market Cap ($Billions)
General Electric	356
Exxon Mobil	309
Microsoft	296
Citigroup	243
Pfizer	243
Wal-Mart	226
AIG	185
Bank of America	181
Johnson & Johnson	173
IBM	145

Company	1994 Market Cap ($Billions)
General Electric	85
Toyota	79
Exxon Mobil	73
Mitsubishi	71
Royal Dutch Petroleum	60
Wal-Mart	60
Coca-Cola	59
Altria Group Inc.	52
Merck	42
IBM	41

the United States appears to be lagging. In Denmark, guidelines for intellectual capital investment were developed through a collaborative effort among researchers, companies, industrial organizations and the government. The UK has developed a self-assessment tool designed to complement traditional accounting tools. The European Union created the METRIUM project (Measuring Intangibles to Understand and Improve Innovation Management) to develop guidelines for the measurement and disclosure of intangible assets. But in the United States, after releasing an initial report in 2001, the Financial Accounting Standards Board (FASB) removed the Intangible Assets project from its 2004 research agenda.

Markets do value investment in intangibles – when they know about it. Today's top ten list of companies by market capitalization, when compared with the top ten from a decade ago, shows the relative ascendancy of investing in human, intellectual and technological capital (See Figure 8).[72] Knowledge-intensive companies generally have a market value that is significantly higher than their book value. But financial statements convey a far from complete picture. And firms with strong investments in intangible assets and well-conceived innovation strategies should be able to enhance their valuations through greater disclosure of intellectual capital and intangible assets.

What is necessary to jumpstart this process is a body of best-practice guidelines and methodologies for companies to follow. Such a framework for voluntary supplemental reporting should complement existing GAAP-based financial statements by creating a common language for companies and investors to communicate about intangible assets and operating performance measures, not a federally prescribed list of indicators that all companies must report.

At the same time, government must participate in the process of identifying best practices and create some safe-harbor provisions to encourage voluntary disclosure. In an environment of complicated certifications, litigation and the potential for regulatory challenges, there is little incentive for voluntary disclosures of supplemental information. However, such disclosures would benefit investors as well as business and more accurately reflect value in the knowledge economy.

Regulatory deterrents to risk-taking

Regulatory controls have created new forms of legal risk for business executives – risks that go beyond more conventional forms of operational or financial risk. Investments that were once considered simply a bet on future value creation can now be the source of legal action. Former SEC Chairman Ralph Ferraro noted that in the effort to put tighter controls on corporate management as a response to recent scandals, we are taking away from business a fundamental right: "the right to fail." He notes that, in this environment, traditional monetary and fiscal policies cannot be successful in stimulating growth because "companies with lots of cash on their balance sheets are afraid to invest in anything, including their own futures."[73]

Without question, high standards of business conduct and transparent reporting are essential. Strong and effective corporate governance ensures that companies do provide the information that investors need – and deserve – to make sound decisions. But dealing with personal legal risk creates a fundamentally different calculus from senior executives than other types of business risks. Instead of weighing the costs and benefits of potential investments, legal ramifications, by definition, will tend to focus attention on strategies for risk avoidance. The problem is that risk cannot be wrung out of the system without eliminating innovation and growth prospects, as well. "The capacity to manage risk and, with it, the appetite to take risk and make forward-looking choices are the key elements of the energy that drives the economic system forward," noted Peter Bernstein in his seminal book on the history of risk and risk-takers.[74]

And signs of defensive management practices are beginning to emerge on Wall Street and Main Street as well.

- PricewaterhouseCoopers's 2004 Global CEO survey of 1,400 CEOs reports 57 percent of respondents stating that the current business climate is making companies either excessively or somewhat risk-averse.[75]
- A number of large-cap companies, including Coca-Cola, McDonald's and AT&T, have stopped providing earnings guidance to investors. A survey of 600 investor-relations executives reveals that nearly a third of respondents said their employers are considering ending the practice of offering performance projections to Wall Street.[76]
- The premiums for directors and officers (D&O) insurance have increased considerably, with effective limits on coverage (e.g., "entity coverage" caps) that in some cases are well below the level of possible damages.[77]

- The number of public companies choosing to go private increased by 30 percent in the 16-month period from August 2002 to November 2003.[78]

There are two dual challenges to address: first, how to overcome defense management practices; and two, how to restore risk-taking and tolerate failure. Both call for a new, open and collaborative dialogue between regulatory authorities, management and shareholders, legislators and special interests.

Regulation has and can shape the environment for investment in innovation in important and positive ways. However, regulators and legislators don't always consider the potential for unintended consequences on the innovation system. More open dialogue between the regulatory and legislative communities and the financial intermediaries of the private sector could improve the calibration of pubic policy to financial market dynamics. Finding the right balance in the regulatory infrastructure is crucial to providing the optimum environment for sustained investment in innovation.

A corollary challenge is to reconsider and revalue the role of risk in the innovation economy. The extension of legal risk into the financial arena mirrors a larger problem the nation – the chilling effect of tort litigation and the massive costs it imposes on the economy. Philip Howard notes: "In any social dealings, whether selling products, managing employees, running a classroom or building a playground, there's a chance someone might be hurt or offended. And in modern day America, that carries with it the risk of being sued." Ironically, what has replaced risk is not a culture of caution, but of blame.[79]

Evidence on the costs of tort litigation to the society and the economy has been mounting for decades. At current levels, U.S. tort costs are equal to a five percent tax on wages, at a cost of $233 billion or more than $800 dollars per person in 2002.[80] But the impacts – and additional costs – can be far more pervasive than the numbers can capture – in defensive medicine, defensive teaching and defensive product management. Ninety-one percent of doctors, for example, report ordering more tests than would have been necessarily based solely on professional judgment – and defensive medicine adds billions of dollars annually to already high health care costs.[81] A Harris survey of public school teachers and principals throughout the nation found that more than three-quarters of those surveyed – 82 percent of teachers and 77 percent of principals – believe that the current legal climate has created a phenomenon that could be called "defensive teaching" – meaning that their decisions are motivated by a desire to avoid legal challenges.[82]

On the liability front, numerous accounts attest to the fact that legal risk has adversely impacted breakthrough technologies in areas like drug development and aviation. Companies are discouraged from performing safety research that could be used against them, or they withdraw from promising product lines.

No one argues that victims of negligence, incompetence or injury are not entitled to some compensation. But the combined effects of uncertainty and the costs of insurance, litigation and awards are having a chilling effect on investment in research, the development of entire classes of products and services – indeed on the innovation enterprise itself.

Recommendations

- Corporate boards of directors should consider incentive and compensation structures that more effectively encourage long-term value creation and innovation.
- Industry should initiate voluntary and supplemental disclosure of intellectual capital, innovation performance and indicators of expected future value.
- Government should enhance the legal and regulatory framework and "safe harbor" provisions to encourage the disclosure of longer-term innovation strategies in a way that enhances investor trust and provides for better disclosure.
- Industry, associations and universities should partner both to educate themselves, financial analysts and consultants on technology trends, innovation performance and management practices, and to support research on comprehensive methodologies for assessing the value of longer-term innovation strategies and risks.
- The impact of new regulations on market investments in innovation should be more carefully and collaboratively assessed by a public-private Financial Markets Intermediary Committee, where periodic meetings can "score" existing and proposed legislation. This committee would follow the model of the Foreign Exchange Committee and Treasury Borrowing Committee.
- The country should set a goal to reduce the costs of tort litigation from the current level of two percent of GDP – some $200 billion – down to one percent.

3. Infrastructure – A Platform for the Future

A major key to a robust 21st century economy will depend on policy and physical infrastructures that enhance innovation. The National Innovation Infrastructure Agenda proposes four initiatives that build on the changing nature of innovation and changing patterns of globalization:

- Create a national consenus for innovation growth strategies
- Create a 21st century intellectual property regime
- Strengthen America's manufacturing capacity
- Build 21st century innovation infrastructures – with the healthcare system as a test bed.

Goal No. 1 *Create a National Consensus Supporting Innovation Growth Strategies*

Innovation is a process of shared responsibilities requiring motivation and integration of many different resources within and among firms, the private sector and governments at all levels. We must create a national consensus that supports innovation growth strategies to meet the challenges of this century. The National Innovation Agenda should include:

- An explicit national innovation strategy and agenda led by the President
- A public-private partnership to advocate for national initiatives and to build broad public support for the NII agenda
- New metrics to track and understand national innovation performance
- A national innovation scorecard to highlight performance results
- National innovation prizes to recognize excellence in innovation performance

Creating a national agenda explicitly based on innovation will require leadership, a solid commitment to making hard choices and a broad-based dialogue among constituents. This is a true challenge. Policy choices often reflect a focus on a single area of concern, without sufficient regard to the consequences it may have in other areas. To optimize for innovation, these choices must be made with a systemic focus on enhancing innovation and economic growth. The nation's leaders must lay out clear, strategic policy choices for our society, with all the stakeholders at the table and with innovation at the core.

Recommendation

An explicit national innovation strategy and agenda led by the President: Innovation is the critical pathway to building prosperity and competitive advantage for advanced economies. Yet no single institution in government or the private sector has the "horizontal" responsibility for strengthening the innovation ecosystem at the national level – it is and always will be a shared responsibility. The United States should establish an explicit national innovation strategy and agenda, including an aggressive public policy strategy that energizes the environment for national innovation.

Innovation strategy merits the time of the President. We ask the President to consider the following action items:

- Establish a focal point within the Executive Office of the President to frame, assess and coordinate strategically the future direction of the nation's innovation policies. This could be either a Cabinet-level interagency group, or a new, distinct mission assigned to the National Economic Council.
- Establish an explicit innovation agenda. Direct the President's economic advisors to analyze the impact of current economic policies on U.S. innovation capabilities and identify opportunities for immediate improvement.
- Direct the Cabinet officers to undertake a policy, program

and budget review and propose initiatives designed to foster innovation within and across departments. This is an opportunity to break down "stovepipes" and foster closer collaboration among the agencies to meet clear national needs.

Recommendation

A public-private partnership to advocate for national initiatives and to build broad public support for the NII agenda: To optimize the nation's innovation performance, the private-sector leaders of our national innovation ecosystem from industry, government, academia, labor and the citizenry must perceive and measure themselves as part of an interconnected ecosystem. They must understand how their own performance interacts with others. This means not only optimizing internal innovation processes but also optimizing externally – the intersections and linkages with stakeholders.

Building upon the recommendations and momentum of the NII, national innovation leaders should establish public-private partnerships to understand and foster the growth goals and needs of each sector. They should communicate, advocate and adopt strategies that propel growth within their own institutions and in society at large. These partnerships should support the communications and legislative priorities called for in the National Innovation Initiative.

Recommendation

New metrics to track and understand national innovation performance: Sound innovation decision-making requires credible, timely and relevant measurements. The United States should establish a new metrics base framed with a national ecosystem outlook. Currently available measurements largely reflect the industrial era rather than the knowledge economy unfolding around us; they largely focus on products and artifacts rather than ideas and processes. A fresh perspective and "real-time" performance metrics are needed to reflect the new paradigm of a global, knowledge-based economy.

This effort can benefit from existing science, technology and innovation indicators, building on them to create a new generation of metrics, with a focus on intangibles, networks, demand, regional clusters, management techniques, risk/return and system dynamics.

These new metrics for the knowledge-based economy can be improved only through a concerted, coordinated and internationally visible effort. The National Innovation Initiative recommends that:

- The federal government should direct appropriate agencies to define measurements most important to quantify today's economy. This work should start immediately.
- Metrics definitions and innovation models should be harmonized or at least made comparable internationally for benchmarking purposes.
- The United States should tap and extract the expertise of the international organizations that conduct extensive policy research, innovation surveys and metrics work, such as the OECD and European Commission.

Recommendation

A National Innovation Scorecard to highlight performance results: The public and private sectors should partner to develop a National Innovation Scorecard on a biannual basis to boost policy attention and sustain a public-private dialogue on ways to adapt the environment for innovation.

This partnership will advance the quality and timeliness of innovation metrics. Implementation of this recommendation

will require a close working relationship with federal statistical agencies, trade associations and professional societies, private research/survey organizations and international bodies.

The Innovation Scorecard would go beyond defining metrics. It would also identify areas of public policy and other factors relevant to innovation performance. A National Innovation Scorecard could be used to focus all stakeholders' attention on critical issues, innovation barriers and alternative actions. It could signal emerging competitive opportunities and threats. Its data could significantly improve investment analysis, reporting on intangibles and risk management, and could support evaluation criteria for government innovation programs.

The Innovation Scorecard should reinforce the public case for a long-term National Innovation Agenda. Benchmarking American innovation performance regionally and internationally will expand public awareness and understanding of the benefits of innovation. The Scorecard findings will act as a force to close gaps in the nation's innovation ecosystem, enhance advocacy and promote a long-term public-private consensus toward superior and integrated innovation policies.

Recommendation

National innovation prizes to recognize excellence in innovation performance: Establish private sector-led national innovation prizes recognizing outstanding innovation performance by businesses, organizations and research and educational institutions that have contributed to the development and diffusion of new products, services and processes.

The national innovation prizes should recognize the underlying innovation processes and organizational environments that generate novel products and services. Beyond recognizing innovative entities, the innovation prizes program would play four important roles:

- Raise awareness about innovation and encourage all U.S. businesses and organizations to adopt innovation as a major component of competitive performance.
- Improve national innovation performance practices, capabilities and results.
- Facilitate communications and sharing of best practices among U.S. organizations of all types.
- Serve as a working tool for understanding and managing innovation and guiding organizational strategy, planning and opportunities for learning.

The private sector would develop the innovation prize criteria, provide expert judges and create a self-sustaining endowment for cash prizes. To achieve self-sustainability, the prizes could be supported by a foundation endowment, application fees and fee-based services, such as innovation conferences and training.

Goal No. 2 *Create a 21st Century Intellectual Property Regime*

Intellectual property protection is a cornerstone of the innovation economy. It ensures that innovators have the opportunity to reap the rewards of their creativity and costly efforts, as well as providing incentives for future investment in innovation. But intellectual property regimes throughout the world face challenges – from the sheer volume of applications, to rapid advances in highly complex technologies, to the necessity for global harmonization and protection. The NII agenda focuses on three areas:

- Build quality into the patent process
- Leverage patent databases as innovation tools
- Create best practices for global collaborative standard-setting

Build quality into the patent process: With more than 300,000 patent applications per year, the challenge of assuring quality patents is increasing. This is especially true where patent protection has been extended into previously uncharted areas (e.g., the human genome) or areas not previously subject to protection (e.g., business method patents). The former have pushed the reach of patents upstream into scientific tools and materials and toward broad concepts that have no clearly defined fields of use. And extending protection to previously unprotected areas has led some to question whether mere extension to the digital world of real-world business practices should be granted patent protection. Yet, at the same time, novel inventions are enabling valuable applications for digital commerce that warrant patent protection.

Because robust investment in innovation is dependent on global IP protection, it is critical that we strengthen the capacity of the U.S. Patent and Trademark Office (PTO), improve the quality of patents issued and shorten the time it takes to get a patent. Patent quality and speed of examination will increase the value of patents to inventors and reduce the need to deal with patents that do not meet patentability standards. Because of the need for regulatory predictability, the NII's recommendations apply prospectively to future patents and future patent applications.

Some recommended process improvements include:

- Increased resources for PTO modernization and patent examination. Experts say that the PTO would have sufficient funds to improve office resources and practices if it could be assured that tens of millions of dollars in PTO fees would not be diverted to non-related purposes. A sustainable resolution of the fee diversion issue should be sought.

- Better compliance with existing patentability requirements, and incentives for improved prior art searches. Innovators have a duty to disclose prior art, but no requirement to search for it – and indeed, the system now provides incentives to refrain from searching. One proposed alternative to reverse the incentive structure is to give patent applicants the option of presenting an expanded information disclosure statement (IDS) that includes explanations of the relevancy of significant prior art.[83] If the patentee were to choose to exercise this option, the issued patent would be granted a specific "presumption of validity" with respect to the disclosed prior art in any later challenge.[84]

- New standards for searchability. Poor search techniques and terminology can undermine patent quality and the usefulness of the patent database. New search standards would make it easier for the PTO to search the patent applications themselves and to extend the prior art search to databases outside the patent office, such as academic papers, technical journals and research reports.

- New online tools for prior art submissions. The PTO should have a means for alerting interested members of the public to published patent applications. In addition, the public should have the ability to submit relevant materials electronically to the PTO following publication, along with reasonable explanatory statements.

- Post-grant patent review procedures. Litigating the validity of granted patents is increasingly costly ($3 million and up), time-consuming (three years) and frequent (32 suits per 1,000 patents). Proposals for the creation of a post-grant review procedure should focus on future patents and patent applications.[85]

Leverage patent databases as innovation tools: There is enormous potential to leverage intellectual property to uncover new intersections between "invention and insight," and, thereby, to turbo-charge innovation by more effectively using information that already exists in patent databases throughout the world. The database of patents represents a detailed record of the discovery process and a map of

"Globalization is causing a shift in the source of competitive pressure, and of competitive advantage, from excellence at the point of production – now more or less assumed – toward excellence in governing spatially dispersed networks of plants, affiliates, and suppliers."

The Technology Industry at an Innovation Crossroads. Electronic Industry Alliance, 2004.

the rapidly evolving landscape of ideas across sectors and disciplines. But the database is not easily searchable. Providing improved searchability on new patent applications will help. PTO should invest in optimizing the legacy database for searches on key patents and establish reciprocal rights to access and search foreign databases.

Create best practices for collaborative standard setting: While IP ownership is an essential driver of innovation, technological advances in many cutting-edge areas are dependent on shared knowledge, standards and collaborative innovation. Patents play, and will continue to play, an important role in facilitating the dissemination of knowledge and technological advances and attracting risk capital to entrepreneurial start-ups. Much shared knowledge and collaborative innovation relies on a standards-based, interoperable, global infrastructure. Indeed, global tools such as the Internet are based upon a mix of open standards and proprietary technology. Such tools have enabled broad sharing and adoption of ideas among companies and across disciplines, while minimizing the impact of geography and time zones.

Having seen the enormous benefits gained when proprietary technologies stand upon standards-based collaborative tools, one objective of the NII is to seek ways, respectful of intellectual property rights, to promote more effective integration of IP in the standards-setting process. Open standards, created through a transparent and accessible process (coupled with the rapid innovation occurring in middleware software) can accelerate the interoperability and expansion of the global infrastructure. Such standards are an important part of the collaborative innovation that will become increasingly important in the 21st century.

From an intellectual property perspective, open and proprietary IP models should not be seen as mutually exclusive; rather, the IP framework must enable both approaches. Because collaborative innovation is relatively new, however, the structure and processes to accommodate ownership, openness and access are evolving. New creative models are emerging across sectors. A mature, balanced understanding of the purpose and practice of standards, including the important role of open standards and global harmonization, is essential to further interoperability, spur technological innovation and expand market applications.

Recommendations

Build quality into all phases of the patent process

- Fully fund the PTO and enable it to direct its fees to fund process improvements.
- Improve compliance with existing patenting requirements and create incentives for improved search and disclosure of prior art.
- Create new standards for searchability of patent applications and new patents.
- Establish a fair and balanced post-grant patent review procedure for future patents and patent applications.

Leverage the patent database as an innovation tool

- Develop pilot projects (jointly funded by industry, universities and government) to highlight techniques for leveraging patent data for discovery.
- Invest in retroactively creating searchable keywords for a subset of the most highly cited historical patents.
- Secure reciprocal access to foreign patent databases.

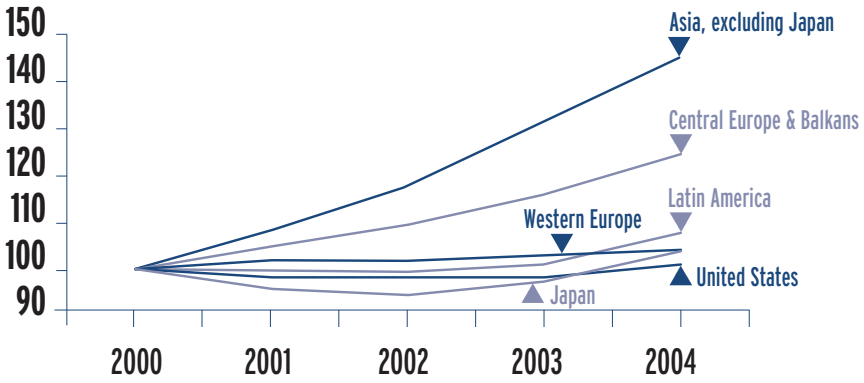
Create best practices for collaborative standard setting

- Set best practices and processes for standards bodies to align incentives for collaborative standard setting, and to encourage broad participation.

Figure 9

Manufacturing Production by Region of the World

Index 2000 = 100



Source: IMF, World Bank, Various Country Statistical Agencies, MAPI

Goal No. 3 *Strengthen America's Manufacturing Capacity*

The United States must have a strong foundation in manufacturing. While the service sector is expanding its global role, manufactured products remain the primary currency of world trade. Although the Untied States remains the world's leading producer of manufactured goods, it now trails among major regions of the world in manufacturing growth (See Figure 9).[86] A revolutionary perspective and approach are needed to reverse this structural trend.

We must put aside the growing perception that America will inevitably lose its manufacturing edge. Instead, we should begin to design and implement a new foundation for high-performance production. This means deploying new manufacturing technologies as fast as they become available. It means integrating new designs, processes and materials in a modular fashion. It means adopting new human, organizational, financial and policy models for a robust future for manufacturing in America.

Planning an Extended Production Enterprise: The manufacturing strategies of cost control, "total quality" and continuous productivity improvement – the hallmarks of America's business re-engineering revolution in the 1980s and 1990s – are now simply the minimum requirements to compete in the global marketplace. In the future, the winning strategy will depend on flexibility, collaboration and speed in an extended production enterprise.

However, manufacturing no longer takes place in a single enterprise or location. Increasingly, the successful 21st century manufacturer is more of a system integrator, managing a supply chain or a virtual network of business process suppliers not controlled by the manufacturer itself.

The next generation of manufacturing will entail new business models that integrate services, design and manufacturing stages throughout the extended production enterprise, creating value "on-demand." Business processes increasingly rely on software, communication technologies and an expanding array of computing devices and sensors to work effectively.

"Globalization is causing a shift in the source of competitive pressure, and of competitive advantage, from excellence at the point of production – now more or less assumed – toward excellence in governing spatially dispersed networks of plants, affiliates, and suppliers." (The Technology Industry at an Innovation Crossroads. Electronic Industry Alliance, 2004).

There is an urgent need to invest in software research and develop standards for interoperability so enterprises have the freedom to share information, collaborate and upgrade applications without significant legacy costs or time delays. The lack of software interoperability is adding to production inefficiencies and poses a major barrier to shortening the design-to-manufacturing execution cycle.[87] For example, the excess carrying cost in the lack of software interoperability in the auto supply chain is more than $1 billion.[88] The annual cost to U.S. industry of weakness in software testing is in the range of $60 billion per year.[89] More interoperability will enable a "network effect" and more efficient manufacturing/service integration.

Key success factors for strengthening America's manufacturing capacity include:

Leveraging our technological advantage: A number of significant trends in manufacturing technologies hold the potential for competitive advantage – flexible automation; complex numerically controlled tooling and advanced CAD/CAM; precision engineering and design; distributed manufacturing; e-commerce that connects supply chains; materials databases; and shared use facilities for R&D and pilot production, that lower the risks and barriers to entry. These technologies hold out the promise of not only significantly increasing manufacturing productivity, but also offsetting lower wage rates in other economies.

Capitalizing on cooperative models and shared facilities: A key ingredient for success will be the development of collaborative models among industry, customers, suppliers, research institutions and government to share the risk, cost and time of development of new technologies. Collaborative models created in the 1980s, such as Sematech and the National Center for Manufacturing Sciences, have played a vital role in manufacturing technologies. But collaboration has been the exception rather than the rule in manufacturing. That must change.

Shared production facilities in highly competitive, high-tech sectors of manufacturing will become increasingly important in strengthening America's productive capacity. World-class centers of production excellence would create an infrastructure that attracts, develops and retains top technical talent; reduces costs through shared facilities; accelerates new product development; and potentially generates start-up companies in new high-growth markets. The long-term sustainability of collaborative models will require leadership from industry and a combination of private-sector and state and local government financing.

Intersecting with national security needs: If U.S. production capabilities continue to shift to overseas locations, and our innovative design and R&D stages follow them offshore, the country will face a major national security problem. We need the most advanced technologies and best manufacturing facilities inside our borders.

The Department of Defense should work collaboratively with industry to reestablish its historic role as a sponsor of breakthrough technologies in 21st century manufacturing processes. These could include distributed and desktop manufacturing, quality inspection that is built into the production process, use of revolutionary materials and methods of fabrication, and devices and machines built at the nanoscale.

Increasing the adaptive capacity of small and mid-size manufacturers: There is perhaps no greater need for innovation than in the small and mid-size manufacturing sector (SMEs). The 350,000 SMEs, which employ more than seven million people and comprise nearly half the U.S. manufacturing base, are confronting enormous challenges to remain viable in today's global economy. Issues facing small manufacturers include disproportionate regulatory burdens; unfamiliarity with changing technology, production techniques and business management practices; difficulty in finding high-quality assistance; access to qualified workers; high health insurance costs; and tight access to capital. These trends raise serious economic survival issues for small manufacturers.[90]

The time is right for establishing innovation as a new mission and focus for the U.S. Department of Commerce's National Institute of Standards and Technology (NIST) Manufacturing Extension Program (MEP) network of 350 centers that has traditionally focused on providing technical assistance in manufacturing operational efficiency and quality.[91] SMEs must become "adaptive" and capable of finding new competitive advantages by looking ahead for market changes, dominating niche markets and rapidly exploiting new technologies and service advantages. Many resources available to SMEs are in regional colleges and universities, federal laboratories, small business development programs and financial communities. However, there is no common framework or process for integrating these resources at the right time and in the right quantity.

The NII proposes that the MEP should refocus on innovation. SMEs could receive assistance regarding technology diffusion, new product development, supply chain integration, innovative use of business services, advanced information technologies and finance strategies. Such centers could assist in integrating federal resources such as the SBIR program and partnerships with federal laboratories toward SME innovation objectives.

Roadmapping technology and federal research priorities: Technology roadmaps represent a consensus regarding industry direction and research needs, innovation trajectories, alternative scenarios and the possibility of disruptive technologies and surprises. Industry

To Out-Compete Is to Out-Compute

Few areas of technology hold more promise for stimulating innovation and propelling competitiveness than high performance computing. Along with theory and experimentation, modeling and simulation with high performance computers has become the third leg of science and path to competitive advantage. There's now in vivo, in vitro and in silica. A recent survey by the Council on Competitiveness of U.S. chief technology and chief information officers revealed that nearly 100 percent consider high performance computing tools essential to their business survival. And they are realizing a range of strategic competitive benefits from using this technology, such as shortened product development cycles and faster time to market (in some cases more than 50 percent faster), all of which improve a company's bottom line.

But we are only beginning to reap the potential innovation and competitive benefits that use of this technology promises. With dramatically more powerful systems, companies can extract trillions of dollars in excess cost through business enterprise transformation. We can revolutionize manufacturing through advanced modeling and simulation of the entire process from raw resource to finished product. We can dramatically accelerate the drug discovery process, and substantially increase oil recovery rates by modeling entire oil fields. By shrinking "time to insight" and "time to solution" through the use of high performance computing, companies in virtually every sector will be able to accelerate the innovative process in ways simply not seen in the past, resulting in new capabilities and revolutionary products and services that capture and cement global market share. As Robert Bishop, CEO of Silicon Graphics, notes, "In the 21st century, to out-compete is to out-compute."

associations and sector-based collaborations should make greater use of technology roadmapping methodologies as an input to the federal R&D priority-setting process, as well as inputs to their own innovation planning. An exemplary roadmapping project, the biannual National Electronics Manufacturing Initiative (NEMI), identifies the 10-year outlook for key technology developments impacting the global electronics industry.[92] Roadmapping exercises can provide the basis for public and private investments in radically new production systems.

Such roadmapping methodologies can leverage the collective expertise of industry without compromising confidential company information, while intelligently influencing federal R&D priorities. Both industry and government mission agencies will have an informed perspective on technological trajectories and help establish priorities for publicly funded research, new product development, business investments and productivity improvement strategies.

Recommendations

- Establish centers for production excellence to accelerate knowledge sharing and commercialization, including a network of shared facilities and consortia for manufacturing excellence.
- Revitalize the Department of Defense's research and procurement to support advanced manufacturing technologies.
- Foster development of industry-led standards for an interoperable manufacturing and logistics systems to accelerate the extended production enterprise.
- Establish prototype innovation extension centers under the leadership of the Department of Commerce to enable small and medium-sized manufacturers to become first-tier partners in the extended production enterprise.
- Expand use of industry-led technology roadmapping projects to define the next generation of innovation opportunities for the extended production enterprise and to advise on federal R&D priorities.

Goal No. 4 *Build 21st Century Innovation Infrastructures – the healthcare test bed*

Despite world leadership in many aspects of health care and research, study after study confirms that the overall U.S. healthcare system suffers from poor quality, high costs, low productivity and limited coverage. Solving these challenges will require many steps, but innovation in our information-based capabilities could prove the most dramatic in the near term.

Building an integrated healthcare capability is truly a grand challenge that requires and embodies contemporary innovation. It addresses a major societal demand; relies on public-private collaboration among many parties; requires common standards, technology and innovative services; cuts across multiple disciplines; and promises enormous economic benefits.

Healthcare spending is 15 percent of U.S. gross domestic product and is rising.[93] Political leaders warn of Medicare insolvency and severe budget shortfalls if current practices remain unchanged. Rising Medicaid costs are draining states' resources – on average accounting for almost a third of their budgets.[94]

Falling birth rates and rising life spans will require the United States to increase efficiency dramatically in health care, as a shrinking share of working-age citizens is asked to support a growing share of older Americans.

The healthcare industry lags far behind other sectors in IT deployment. Studies estimate that the United States spends up to 31 percent of its healthcare dollar on administrative paperwork.[95] A PricewaterhouseCoopers study for the American Hospital Association found that caregivers spend more than 30 minutes on paperwork for every hour of patient care.[96]

The problem is literally a matter of life and death. The Institute of Medicine estimates that America suffers up to 98,000 avoidable deaths annually due to medical errors.[97] Even more Americans suffer disabilities or complications due to inappropriate or missed treatments. Modern IT capabilities would reduce prescription errors, alert doctors to drug interaction risks and facilitate more individualized treatment.

Modern infrastructure would expand care in remote areas and enable patients to take a more active role in their own health management. It would facilitate improved research, speed health innovations to market and improve America's ability to address outbreaks of infectious disease or bio-terror attack.

Health care also is a critical component of U.S. economic competitiveness. Rising health premiums are raising the cost of U.S. production, making our country a less attractive investment environment and a weaker export platform.

Building network infrastructure for health care also is a strategic growth strategy. Virtually every developed country faces even greater aging dilemmas with less reformed or more generous benefit programs than the United States. We should partner with other nations to collaborate electronically on trans-border health issues and research, creating opportunities to export not only good will and good health, but also U.S. healthcare management and technology.

Recommendations

The United States should build an integrated healthcare capability by the end of the decade. The federal government and industry must set strategic goals and use established performance measures that have been developed and vetted through the National Quality Forum, recognized accrediting bodies and the Agency for Healthcare Research and Quality (AHRQ), based on health outcomes. The federal government should assist state and regional initiatives that pursue the strategic goals. Government at all levels can lead by being an early adopter of new technology and applications. Industry must lead in establishing interoperability standards and other protocols that serve as platforms for innovation by many players, through a variety of applications and devices.

Significant portions of this work are underway through the Department of Health and Human Services' (HHS) newly formed Office of the National Coordinator for Health Information Technology (ONCHIT). ONCHIT released a July 2004 framework with four major goals: (1) bring electronic health records into clinical practice; (2) interconnect clinicians so health records can move with citizens; (3) enable individuals to manage their care more effectively through access to personal records, customized guidance and information about clinicians and facilities; and (4) improve reporting for public health and research.[98]

The National Innovation Initiative supports these goals and recommends steps that would strengthen and augment them:

- The Centers for Medicare and Medicaid Services (CMS), the Centers for Disease Control (CDC), and the Food and Drug Administration (FDA) should accept electronic reporting by the end of the decade from hospitals, physicians and other regulated entities.
- Industry should prepare health IT "readiness guides" so governments and healthcare entities can pursue clearly defined steps to move from goals to implementation. The guides would include private and public action steps, such as enabling electronic exchanges by reforming certain state licensing rules and portions of the Health Insurance Portability and Accountability Act (HIPAA).
- The IT infrastructure being deployed to comply with the Medicare Modernization Act should be leveraged to build an integrated IT infrastructure for health care. Rather than building isolated IT silos within CMS, the government should build an integrated platform for managing healthcare data across CMS, CDC, the FDA and the private sector, including care providers.
- We should fund research and university programs that explore ways to apply modern management and efficiency practices to healthcare delivery. This type of process innovation will speed the transfer of new knowledge into patient services and expand access to care.
- The United States should establish pilot programs for international electronic exchanges by 2010 for public health, research and healthcare delivery between the United States and at least one country on each continent. Such programs would expand care for Americans and establish a platform to export U.S. medical excellence. Appropriate privacy and security safeguards should be required.
- States and companies should expand the use of performance-based purchasing agreements that create incentives to reduce medical errors and achieve other health outcomes. Government should partner with employers, providers and insurers to encourage such instruments. HHS and Congress should support CMS pay-for-performance demonstration programs that would reward clinicians for delivering high-quality care, not simply the highest volume of care.

LOOKING AHEAD

"Horizon Two" Imperatives for an Innovation Economy

A number of the Working Groups of the NII identified some key national priorities that, while not specific to near-term stimulation of innovation, do underpin the nation's ability to innovate. Although they are not the focus of the NII's current action agenda, a failure to address them would erode our innovative capacity, as well as the nation's economic and social viability. Four areas of concern stand out.

1 Unfunded Liabilities

Investing in innovative technologies, products or services requires fundamental confidence in the stability of the economy and capital markets. NII experts pointed to the large build-up of unfunded liabilities in Social Security and health care as a cause for serious concern about the future. They note that even assuming modest growth rates in inflation and healthcare costs, the present value of the 75-year obligations will create an unfunded liability of $11 trillion, equal to our annual GDP. By 2078, the total spending on just Social Security and health care for the Baby Boomers is forecast to reach more than 20 percent of GDP (versus less than seven percent today), an amount that could leave no money for any other government spending.[99]

2 K-12 Education

For much of our nation's history, finding an entry-level, relatively low-skilled job from which to advance was easy. In fact, it was the embodiment of the American dream. But global competition is putting an increasing premium on skills and education, now the price of admission to the middle class. For America's workers to engage productively in the global economy, they must be better prepared to succeed in the global skills race.

That process begins with K-12 education. The mediocre performance of American students on international assessments in science and math is proof enough that elementary and secondary schools are not making the grade. One of the worrying trends is that performance actually declines as our students progress through school. In the 4th grade, U.S. students score above the international average in math and near first in science. By 8th grade, they score below the international average in math and only slightly above it in science. By 12th grade, U.S. students are near the bottom of a 49-country survey in both math and science, outperforming only Cyprus and South Africa.[100]

And that is only the beginning. For the future, the nation will need a workforce equipped with more than literacy in reading, math and science. We need a whole generation with the capacities for creative thinking and for thriving in a collaborative culture. We need a class of workers who see problems as opportunities and understand that solutions are built from a range of ideas, skills and resources. However, there is little in the curriculum of even our best elementary and secondary schools that builds these skills. Created at the turn of the last century, the mass-education system emphasizes the kind of rote learning appropriate for a mass-production economy, rather than the collaborative, problem-solving skills workers will need for the innovation economy.

3 A Global Trading System

Powerful trends that reinforce and broaden the global sweep of research, innovation, business and trade are offset by a dense thicket of overlapping and incompatible rules, laws and jurisdictions, from local and national to supra-national.

For instance, rules protecting intellectual property are fundamental to innovation, particularly in a digital world of quick and nearly perfect replicability. But the IP rules have not kept pace with technological or business change – reflecting more of a 1980s style of innovation and type of intellectual property than a 21st century one. And the rules are flouted by some countries, seemingly at will.

American innovators are equally handicapped by the lack of consistent global rules on competition policy. Businesses and transactions are caught in a complex web of conflicting standards – and anti-trust

rules are used as a means to restrain trade rather than expand it. Some countries have created barriers to new technologies by mandating the use of particular technical standards or requiring cumbersome product testing, certification and licensing procedures.

Innovation in today's global economy cannot reach its potential without effective access to markets, effective protection of intellectual property, international approaches to standards development and transparent competition policy. In short, there must be an international rule of law that supports global innovation.

4 A 21st Century Infrastructure

In the late 19th and 20th centuries, the United States pioneered the world's most advanced infrastructure in transportation (railroads, highways, air travel), telecommunications, energy, water and waste management. But this infrastructure is deteriorating – some would argue, decaying. The American Society of Civil Engineers gave America's physical infrastructure an overall "D" grade, estimating that $1.3 trillion would be needed just to bring it back to acceptable conditions and functional performance.[101] Very visibly, the power blackout of 2003 pointed up shortages in electricity generation and transmission.

Without world-class infrastructure across the board, it is impossible to conduct world-class research. But in the 10-year period from 1988 to 1998, the amount of laboratory space at universities needing repair or renovation increased in every S&E field and doubled in some, with an $11 billion backlog.[102] A 2001 report to the Director of the National Institutes of Health estimated a need for $5.6 billion to address inadequate or outdated biomedical research infrastructure.[103] The Department of Energy reports that above 60 percent of the the laboratories and facilities of the Office of Science are more than 30 years old, identifying upwards of $2 billion in needed capital investment.[104] Even the Internet, the marvel of modern communications, needs an upgrade. In 1985, the Internet connected 2,000 computers. Today, there are more than 233 million Internet hosts and more than 812 million users.[105] The Internet of the future must be able to connect billions of information appliances, like computers, portable devices, wireless modems, GPS locators and sensors. The current infrastructure was not designed to support this explosion of users and devices – and much more investment will be needed to transform the technology and support innovation.

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The Council sets an action agenda to drive U.S. economic competitiveness and leadership in world markets in order to raise the standard of living for all Americans. We focus on strengthening U.S. innovation, upgrading the workforce, and benchmarking national economic performance. Our members are corporate chief executives, university presidents and labor leaders. Our national affiliates include nonprofit research organizations, professional societies and trade associations.

How We Operate

The Council shapes the national debate on competitiveness by concentrating on a few critical issues. These issues include technological innovation, workforce development and the benchmarking of U.S. economic performance against other countries. Members and Council staff work together to assemble data, develop consensus-based recommendations and implement follow-up strategies in every region of the country. Our work is guided by a 31-member Executive Committee. A staff of 18 provides research and operational support. Chief executives from 17 of the country's most prominent nonprofit research organizations, professional societies and trade associations contribute their expertise as national affiliates of the Council. The Council on Competitiveness is a nonprofit, 501 (c) (3) organization as recognized by the U.S. Internal Revenue Service. The Council receives funding from its members, foundations and project sponsors.

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