Innovation

The New Reality for National Prosperity

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National Innovation Initiative

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21st Century Innovation Working Group

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Summary of Recommendations

Recommendation # 1: Elevating Innovation as a National Priority

Innovation should be embraced by the President as a fundamental national objective and a crucial issue for US economic leadership, competitiveness and prosperity. The 21st Century Working Group's recommendations to address this objective include:

1. **Establish through Presidential directives a Cabinet level interagency mechanism to strategically frame, assess, and coordinate the future direction of the nation's innovation policies.**
2. **Develop in partnership with the private sector innovation metrics, models and policy frameworks that better reflect the global, knowledge based, networked economy.**
3. **Promote public understanding of the benefits of innovation.**

Recommendation # 2: Retooling Skills for Innovation

Education, both at the college level and in K-12, should be significantly changed and realigned to prepare students to be leaders and innovators. One essential target for reform is in the area of curriculum, where creative and integrative instruction based on Problem-Based Learning (PBL) should be developed and implemented. New methods of teacher training, school organization, governance, incentives and accountability must also be addressed to support and sustain the newly-aligned system.

Recommendation # 3: Catalyzing Investments in Innovation

Innovation requires research investment and collaboration between many parties, including large, medium and small companies, universities, and government. Collaborative arrangements can result in higher innovation productivity. Effective collaboration demands new mechanisms. The 21st Century Working Group's recommendations in this area include:

1. **Strengthen knowledge networks between appropriate partners, both virtual and real by establishing a National Innovation Portal, an open-source forum for innovation that matches companies with appropriate partners.**
2. **Enhance federal and state funding for research and innovation, especially merit-based programs (cf. NSF, NIH, DOD, DOE, DOC, and state programs) that match or provide funding in all technology areas according to technological and commercial promise.**

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1. Introduction

Innovation is the pathway to future prosperity. By most historical measures the US is the leading innovator in the world. It has in place most of the fundamental capacities for future innovation. However, the present challenge is one of insight on the nature of global innovation--whether we understand the new realities of the knowledge based, networked economy and how well we can redesign our innovation polices to sustain a long-term rise in US living standards. The advanced industrial economies of Europe and Asia have made innovation a top priority to secure their success in the global economy. Developing economies such as China, India, Brazil and Russia are committing substantial resources to move up the innovation value chain and are becoming important players in the marketplace. The United States must meet this challenge in ways we *all* participate and *all* benefit.

21st Century Innovation Working Group

During the past four months, the 21st Century working group has focused its effort on discovering the attributes of innovation success, identifying priority issues and connecting our insights into an overall framework for guiding innovation policy. In this Interim Report, the Working Group makes a case for the importance of innovation, proposes a definition for innovation, describes the changing nature of innovation and makes action recommendations on the following seven cross-cutting issues:

1. Government Policy Coordination for Innovation
2. Innovation Metrics
3. Public Attitudes to Innovation
4. Education Policy and Curriculum
5. Industry Competitive Dynamics
6. Virtual Knowledge Networks
7. Innovation Management Practices

Our analysis and recommendations to date suggest that a dramatic change in the nation's approach to innovation is now required if we wish to sustain our long term economic growth and competitive advantage. The recommendations are proposed as part of an overall framework aimed at creating a more robust environment for both the private and public sector to innovate, collaborate and rapidly respond to the growing spectrum of technology and market opportunities. Government polices should facilitate, not impede, this market driven transition to an "innovation economy" that is global, creative, adaptable and continuously nurtures, commercializes and supports "new-to-the-world" technologies.

At this point in the NII process, we realize that our analysis continues to evolve with additional questions and issues to be resolved. Innovation is inherently dynamic and constantly evolving. Perhaps no innovation framework can or should be definitive and final.

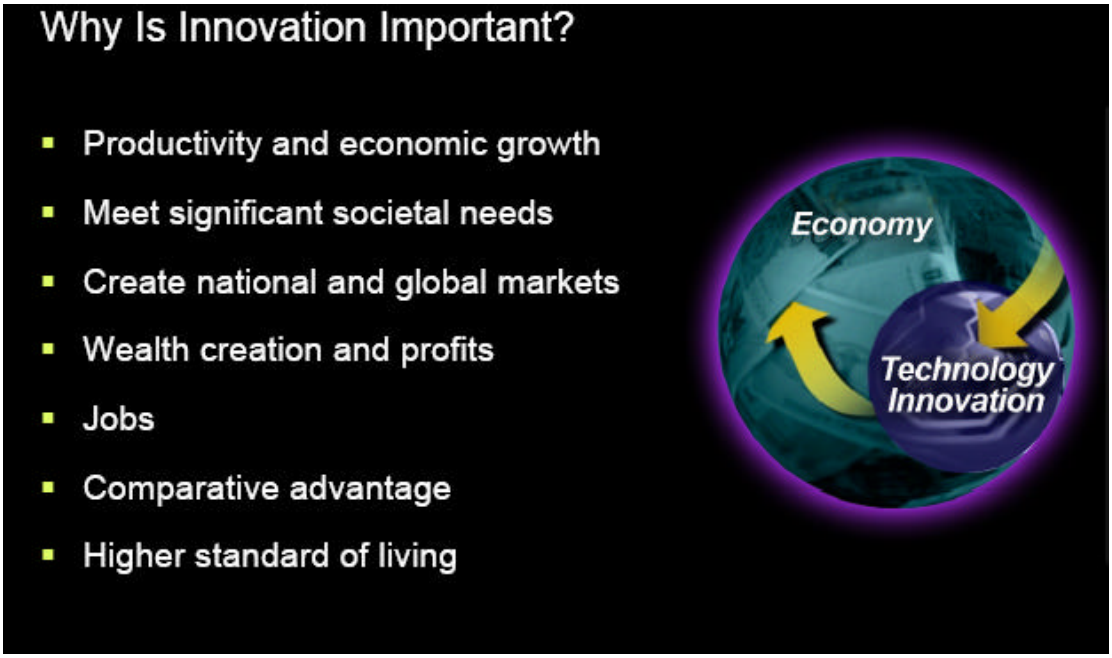
2. The Global Innovation Challenge

WHY INNOVATION IS IMPORTANT

Historically, large economic advances in the US were built on multiple advances in technology and their application in the marketplace. Breakthroughs such as electricity, mass production of automobiles, telephone, television, microprocessors, computers, genetic engineering, wireless devices, etc, were followed by substantial increases in business activity, economic growth, productivity and living standards.

According to leading economists, nearly half of US productivity growth is accounted for by technological progress, capital investment and the skills and experience of the workforce (Solow, Kendrick, Denison, Jorgensen and Romer). International comparisons of economic performance indicate that the *intensity of national innovative activity* is correlated with higher rates of productivity growth and standards of living (Porter, Furman, and Stern).

Successful innovation creates customer value through new products and services, gives rise to new markets, and generates growth for enterprises. Innovation improves existing products and processes, thereby contributing to higher productivity, lower costs, increased profits and employment. Firms that innovate have higher global market share, higher growth rates, higher profitability and higher market valuations. Innovation also generates spillover and cascading effects as competing firms absorb new innovations. Customers of innovative products and services gain benefits in terms of more choices, better services, lower prices and improved productivity. As innovations are adopted and diffused, the "knowledge stock" of the nation accumulates, providing the foundation for market growth, long-term wealth creation and higher living standards.



THE NEXT INNOVATION WAVE

For the US to maintain high levels of economic growth and job creation, it must be a global leader in the development and commercialization of "new-to-the-world" technologies. Incremental improvements, imitation and adaptation continue are important for maintaining competitiveness. However, this is not a sufficient foundation for long-term competitive advantage, economic growth and rise in living standards. The nation must now develop a true innovation capability and generate exponential rather than linear improvements.

During the 1980s the United States faced a competitiveness challenge primarily from Japan. To meet this challenge, policy attention was focused on cost reduction, operational efficiency and quality improvement. The economy successfully transitioned from a mass-production to a quality-management culture, where ideas such as lean, six sigma, TQM, do it right the first time and supply chain optimization created the productivity marvel of the world. Today, cost and quality are the minimum ante to be a player. The forces of global economic integration and advances in technology are creating a different and more complex challenge. Sustaining competitive advantage requires moving beyond efficiency and quality toward creating new markets, increasing value to customers and innovating continuously on a global basis.

The US must create the conditions that will stimulate enterprises to innovate and take the lead in the next generation of technologies and launch the economy onto new growth curves. The transition to a globally integrated economy portends to be more disruptive in its reach, scope and scale than prior waves of innovation such as the shift from mass production to quality management. But it is a challenge we must meet.

While innovating enterprises are the prime agents of knowledge transformation and commercialization, innovation is increasingly a global and interactive activity among many stakeholders, including customers, government, academia, the financial sector, research centers and partnerships. The 21st Century Working Group examination of innovation points us toward an integrated policy framework which gives major consideration to factors not only *internal*, but also *external* to the enterprise, including *market demand*, *public policy environment* and the *innovation infrastructure.* These are recognized as important determinants of national innovation performance.

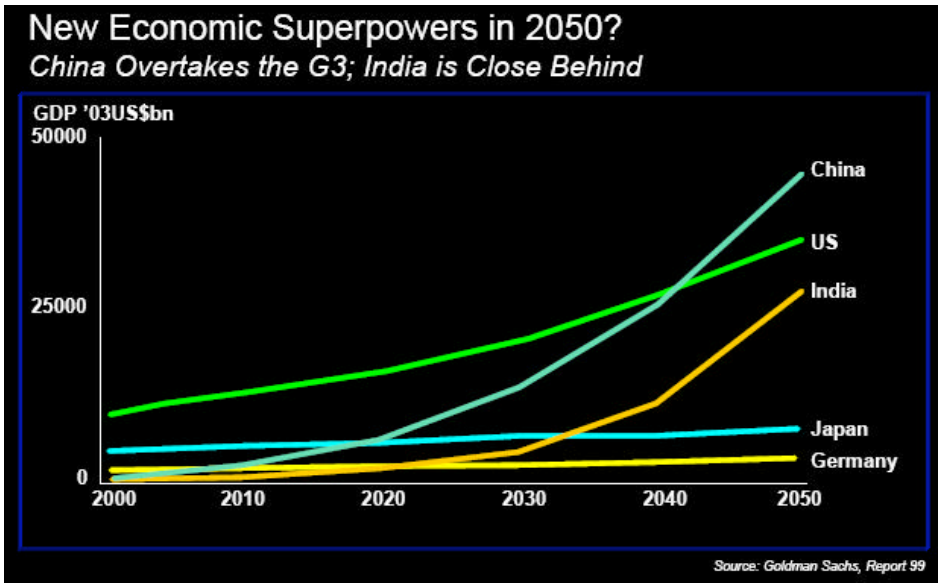
GLOBAL INNOVATION CHALLENGERS

Other nations are now viewing innovation as the key to their future growth and economic well being. During this past decade the European Community has focused policy attention on building more creative innovation systems (Lisbon Strategy). Their innovative capacity is being strengthened with the EU accession of 10 talented and motivated countries of the former Soviet Union. Individual nations, such as the United Kingdom, Germany and France, are also establishing national innovation strategies. Japan, Taiwan, Singapore and South Korea are systematically focusing on the next wave of technologies to drive their economies to become even more competitive in international markets. China is an emerging nation, although representing just four percent of the global economy today, but

it is growing rapidly. India has established a major foothold in software development, manufacturing and high tech outsourcing.

Despite this global growth, the United States remains the world's economic superpower, accounting for a third of global economic activity. We cannot lose sight of that. But our future is indeed being challenged. The projection shown below reminds us that the time is now to get our act together. Over the next 50 years, Brazil, Russia, India and China—the BRICs economies—are forecasted together, in US dollar terms, to be larger than the G6 countries of the US, UK, Japan, Germany, Italy, and France. By 2025 they could account for over half the size of the G6 and by 2025 only the US and Japan may be among the six largest economies.

If the assumptions of the forecast hold up, the BRICs will become a major engine of new demand growth. This growth is a global opportunity – a change to raise the standards of living of millions. As Americans, we should welcome this, because prosperity increases markets and breeds stability. However, we need to make thoughtful choices across many dimensions to ensure that Americans compete effectively in a hyper-competitive global economy and continue to enjoy the high standard of living they expect. The US challenge is to put in place policies, strategies and investments that allow us to participate in a way that all benefit.



3. Innovation Defined

The traditional conception of innovation is a linear progression from research to invention, from engineering to product, and from manufacturing to marketing. That model would suggest that the method for increasing innovation by increasing R&D inputs (technology push) would be sufficient. Innovation, however, is much more complex than a sum of knowledge inputs. It is about successful market outcomes and the process by which those outcomes are generated. Accordingly, the 21st Century Working Group has defined innovation as follows:

"Innovation transforms insight and technology into novel products, processes and services that create new value for stakeholders, drive economic growth and improve standards of living."

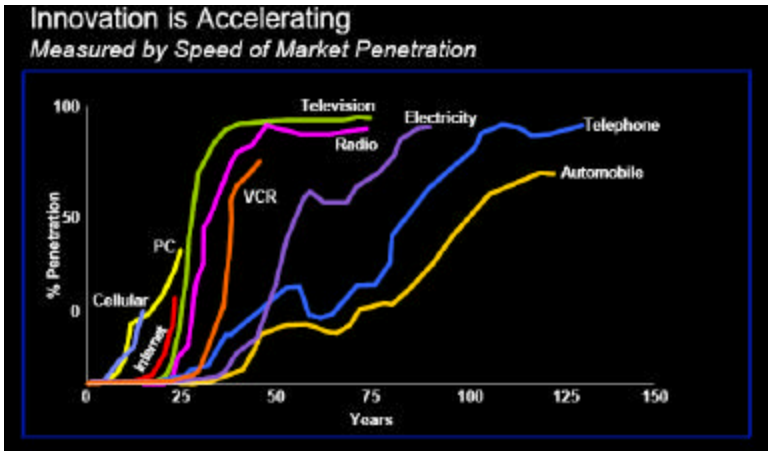
The definition respects the fact that innovation is a complex and multidimensional activity that cannot be characterized by a single input measure. Our understanding of innovation is significantly hampered by currently available (and inadequate) measurements that largely reflect the industrial era and less so the demand driven, knowledge economy unfolding around us: they largely reflect products and artifacts rather than ideas, processes and customer value creation.

- Innovation is much more than technology – many other complementary resources and services are essential for market success;
- Like human health, there isn't any single attribute adequate to capture innovation's dynamics and multiplicity of features;
- Innovation success and diffusion is ultimately determined by the demand side (how the customer values innovation) not just technical inputs and product features.
- Companies are moving beyond the dichotomy of technology push and market pull and are embracing both sides of the equation by collaborating more with customers, partnering with external sources of innovation, networking resources into new business models and focusing innovation on global market opportunities.
- Non-linear dynamics characterize the entire innovation value chain end-to-end at the national level and at the firm level.

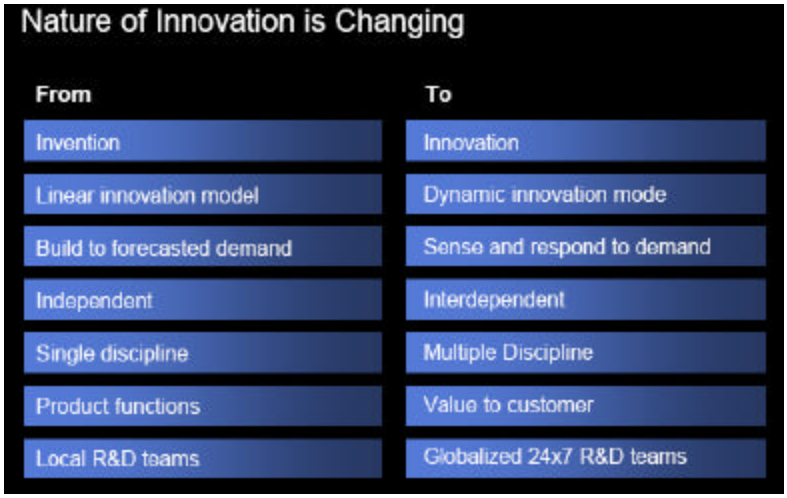
4. The Nature of Innovation is Changing

ACCELERATION OF INNOVATION

Historically, innovative devices have transformed our society and economy at a relatively slow rate. However, the penetration rate of these devices is accelerating dramatically, as indicated in the following chart. It took the automobile 100 years to penetrate 50% of the global market. It took the telephone 75 years and electricity took 50 years. By comparison, the rise of cell phones, for example, has been nothing less than meteoric -- faster than the personal computer ... faster than the Internet.



With the slower pace of innovation, the traditional linear innovation model worked pretty well. However, today's model is more dynamic. In the past, we built to forecast and demand. Today, we must sense and respond "on demand." To do that, we can't be independent workers in silos anymore. We have to think in an inter-dependent, collaborative way. We have to think across disciplines and collaborate at the intersections between them. Contemporary innovation requires that we move beyond our earlier concerns of, "How can I make my product better?" Today, our focus must be on the value a product or service brings to the customer. What are customers demanding, what do customers value most, and what will create additional value in the future?

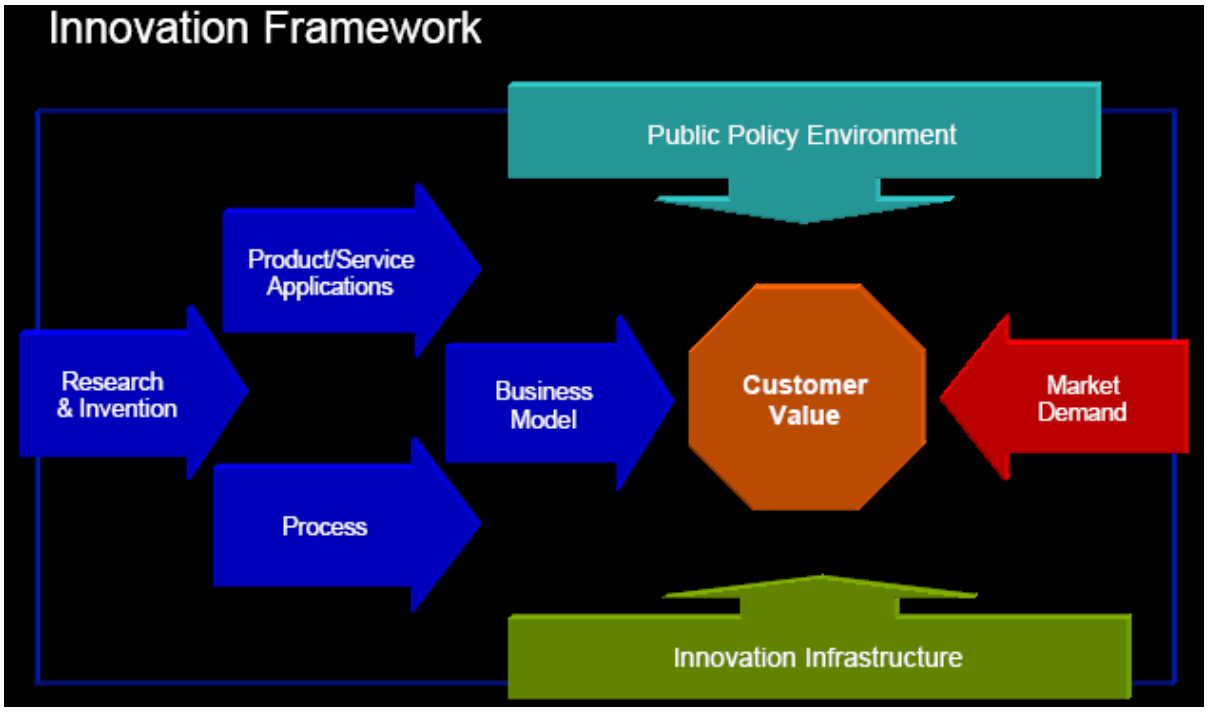


INNOVATION FRAMEWORK: BEYOND INVENTION

With these observations in mind the Working Group has evolved a comprehensive perspective on the nation's innovation system. Traditionally, innovation policy has focused on inputs--in terms of research and invention and in terms of training scientists and engineers and creating the skills they will need. With those resources, it has been assumed that the United States would be able to create competitive products and services and related production processes. We also, in more recent times, have focused on business models and customer relationships processes. However, these are only "inputs" to the market. Today, we need to think about moving beyond those isolated inputs by approaching innovation in terms of customer value creation.

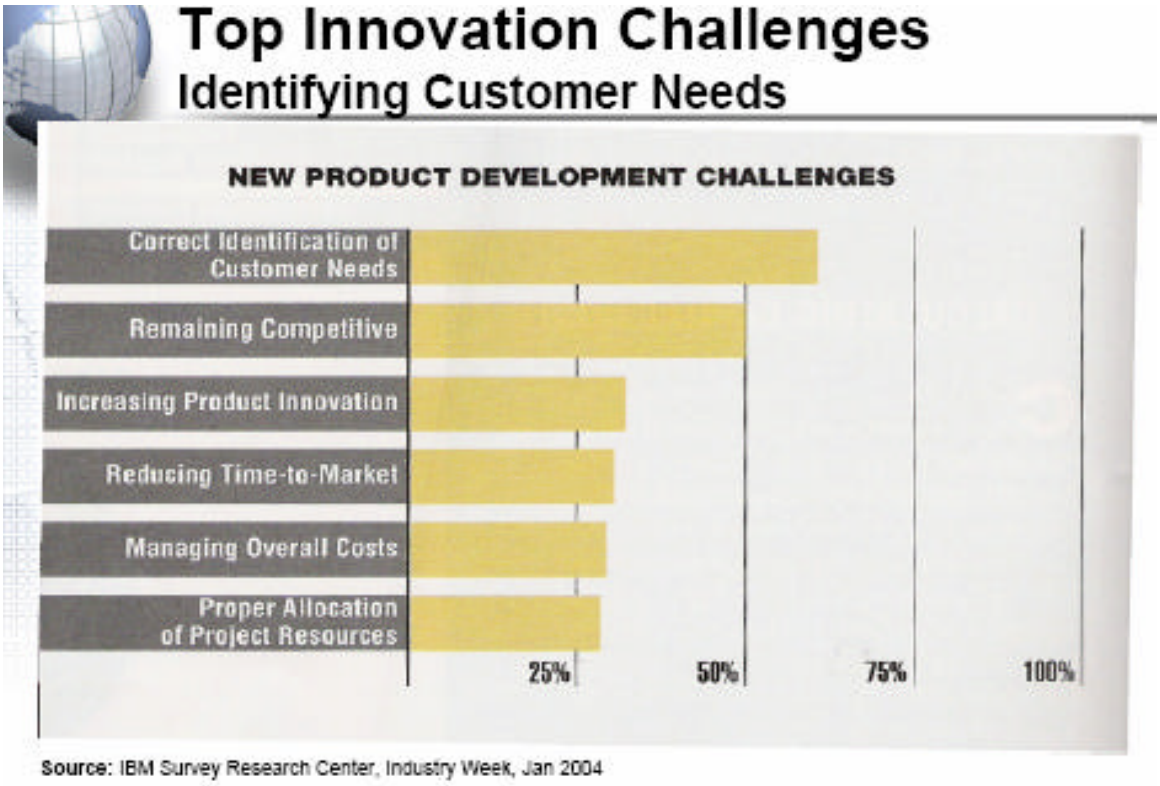
The framework presented below helps describe the "national innovation ecosystem." and focuses attention beyond invention to key measurements and policy issues. The framework recognizes the importance of:

- Both technology inputs and market demand (outputs) as factors influencing the rate of innovation.
- Attributes of the innovation infrastructure and public policy environment as important determinants of national innovation outcomes.
- Processes, management practices and linkages between the inputs and outcomes.



More insight on *market demand* and *customer value creation* will increase the search for innovative solutions, help manage risk, accelerate diffusion (take-up) and significantly mobilize the nation's innovation resources.

According to a recent survey of new product development challenges the top priority of business leaders is correctly identifying customer needs. (See Chart below)



The innovation framework also helps us ask important questions. For example if the nation's *infrastructure* is adequate to the task:

- Do we have the right collaborative mechanisms and methods of bringing university industry partnerships together?
- Is our research infrastructure adequately funded and organized effectively to support innovation?
- Are we investing in the physical sciences, as well as in the life sciences?

Equally important, we need to ask whether we have the right *public policy environment* to facilitate innovation processes and enable continuous delivery of value. A broad array of government polices from research funding to taxes to market access have important impacts on the innovation process. Presently these policies managed vertically in silos and are not examined or integrated horizontally by the government from the perspective of innovation. Table 1 illustrates the diverse ways these policies can facilitate or pose a barrier to innovation.

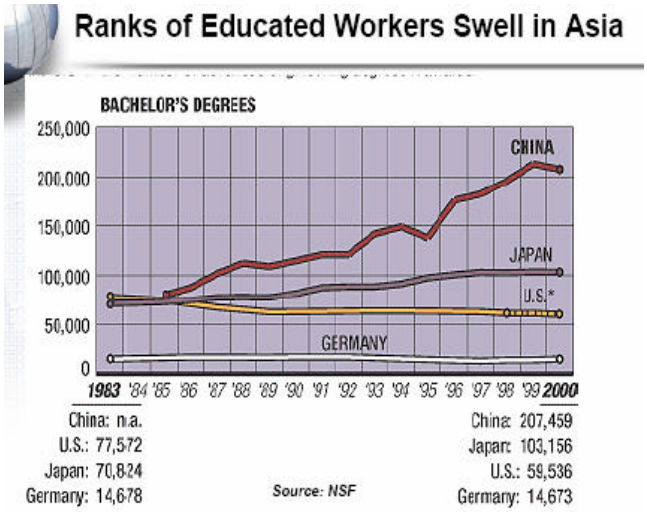
Table 1 - Public Policy Impact on Innovation

Public Policy	Examples of Innovation Impact
R&D Funding	Impacts scientific direction (e.g., life sciences, nanotechnology, advanced computing) and production of scientists and engineers. Supports innovation infrastructure of universities, research centers, federal labs, industry research. Specialized programs like ATP support pre-competitive collaboration. MEP supports small manufacturers and SBIR technology-based start-ups. Public R&D goals and administrative procedures can conflict and misalign with private sector goals, expectations and management requirements.
Macro Fiscal and Monetary Policy	Cost of capital for innovation and rate of national economic growth influence investment decisions, available earnings, stock market valuation of innovative enterprises, etc. Currency policy, foreign and domestic, impacts international competitiveness.
Technology Transfer	Bayh-Dole Act and Federal Tech Transfer Act impact the incentive for industry-university-lab collaboration and rate of knowledge flow to innovators
Human Resource Policy	Federal education and training programs, education subsidies and research funds to support universities are a determinant of the supply of qualified workers needed for scientific research, development, and commercialization of innovation.
Tax Policy	Provides R&D incentive. Rate of depreciation affects transfer of knowledge embedded in new capital. Provides level of incentives for consumers to adopt innovation.
Standards	Facilitates platform technologies, such as Internet, computing systems, software and interoperability. Standards can also function as a barrier to technical change and can restrict markets.
Procurement	Government can stimulate market and standards development through large-scale aggregation. Design specifications can restrict introduction of new technologies.
Antitrust	Can encourage industry innovation collaboration. Encourages new market entrants. Can introduce delays in innovation introduction.
Intellectual Property	Acts as incentive for innovators. Can restrict entry of competitors. IP protection can be weak globally, reducing return to innovation.
Market Access	Choice and access to foreign markets, export conditions and foreign direct investment influence market potential, risk and growth. Export controls can inhibit competitiveness.
Economic Regulation	Impacts innovation investment through pricing control, rates of return, market share restrictions and entry of competitive alternatives.
Social and Environmental Regulation	Can act as stimulus to innovation and also impact performance parameters of innovation. Type of regulation also impacts industry costs, relationship to suppliers and employment conditions.
Health Care Policy	Major driver of business cost of operations. Demographics and growing demand for health care creates opportunity for new products, services and productivity-enhancing technology
Privacy	Public concern creates additional demand for protecting information flows and assets.
Homeland Security	Creates government market for innovation, and creates additional economic requirements for managing risks and vulnerabilities of most economic sectors, including information industry, financial industry, water, energy, transportation, manufacturing supply chains, etc.
Employment & Manufacturing Initiatives	Current political pressures add to protectionist risks, constraints on global investment, "buy America" provisions, employment transition costs, and higher skill standards.

5. Key Trends and Issues Make Innovation Vital

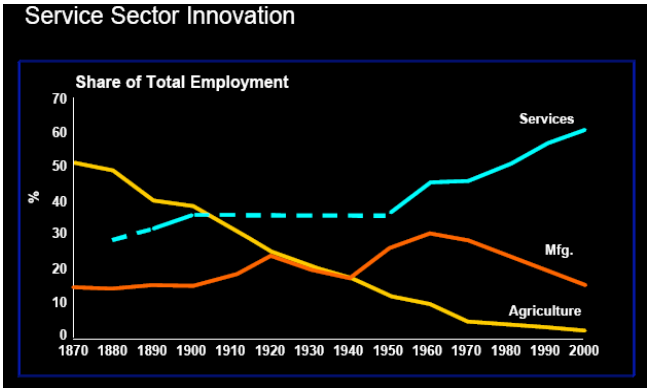
Global Talent Pool

Several nations are producing more educated workers than the US. As a result, we no longer can rely solely on US talent. Nor should we want to. We want to benefit from a diversity of talent ... a diversity of culture ... a diversity of thought and insight. We want to draw people from all over the world into our innovation networks. Innovation is happening everywhere. The research capabilities of universities are growing -- both here, and in other nations. To take advantage of global talent, we should encourage the growing focus on collaboration as a "win-win value proposition" that engenders benefits for all partners. For the US workforce, a central challenge for educators is how to radically redesign our education pedagogy and curriculum to produce lifelong learning skills so current and future generations can be more flexible, mobile and prepared to compete successfully in the globally competitive knowledge intense economy.



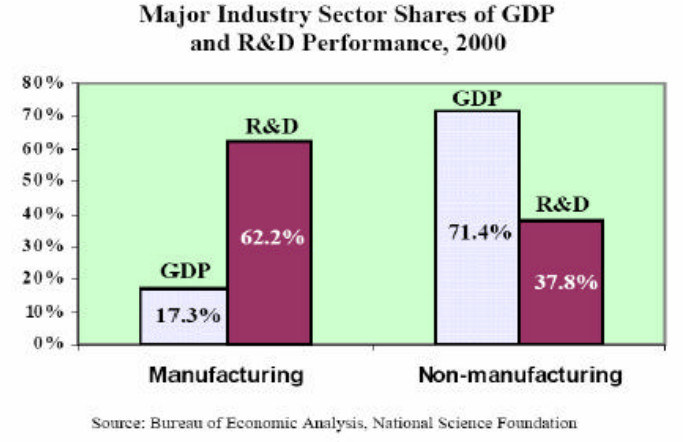
Service Sector Innovation

Our *services* economy is growing, while the *manufacturing* portion of our economy is declining. A key issue is whether our education system is training young people to participate in this new kind of business structure. We need the correct statistics in place to measure the many changes that go along with this shift toward a knowledge based services economy?



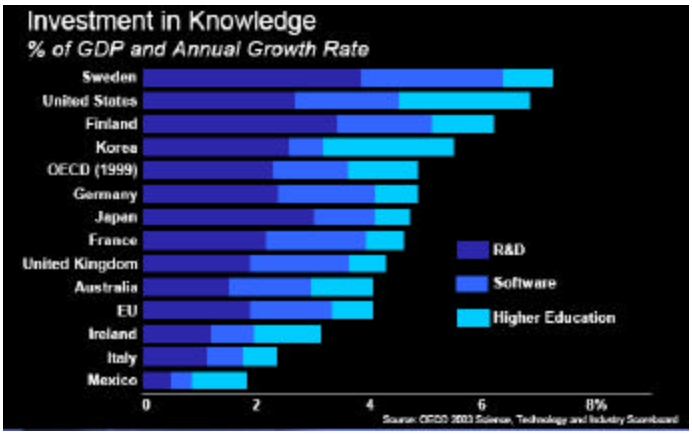
Services R&D Significantly Below Manufacturing

Innovation policy needs to address the proper balance in research investment. Manufacturing represents just 17% of our economy. Yet, we're devoting nearly two-thirds of our research to it. Over 71% of our economy is represented by Services, but we are investing only a 37% of our research investment to it. A better alignment may be in order.



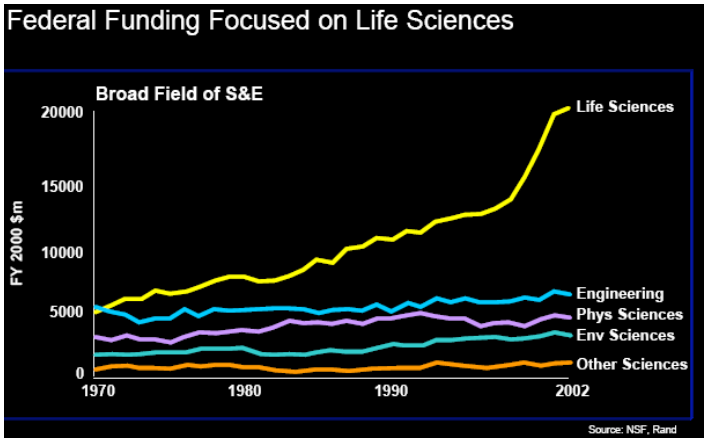
Investment in Knowledge

The United States is second only to Sweden in percentage of GDP in knowledge. Looking to the future, we will be required to bring together a range of disciplines to drive the production, aggregation and distribution of knowledge through Information Technology.



Federal Funding Focused on Life Sciences

Life Sciences are the hotbed of discovery and innovation right now, and perhaps one of the great drivers of economic growth and customer value in the future. On the other hand, we are virtually ignoring the physical sciences that will enable growth of the engineering and Information Technology fields -- which are critically important elements of the innovation infrastructure.

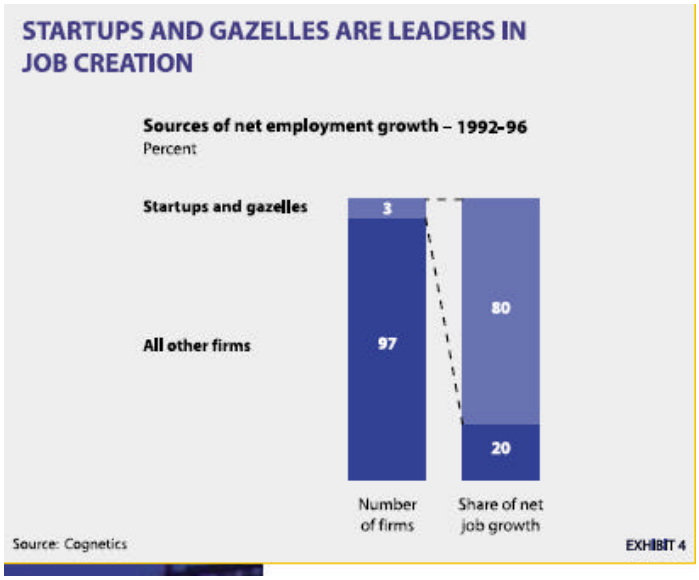


US is Global Leader in Venture Investing

Although higher risk investment capital has diminished since the exuberant stock market days of the late 1990s, the US continues to lead the world in venture investments for innovation. However a growing proportion of those investment dollars are from non-US citizens. Steps are needed to maintain a high level of venture capital investment in the US especially considering the large trade deficit and falling value of the dollar.

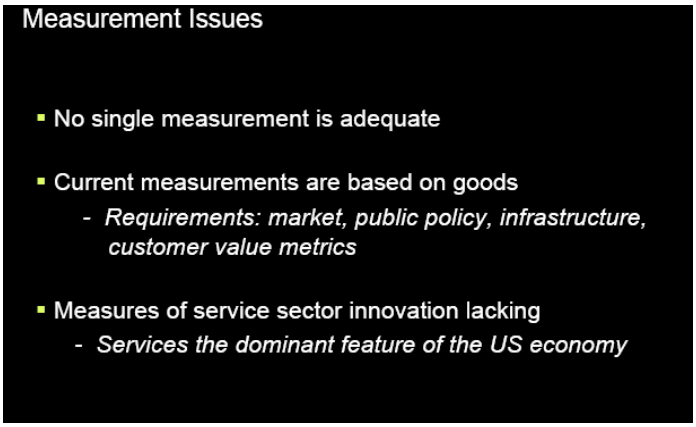
Small Firms are the Job Creators

Most new jobs come from a relative handful of fast-growing companies. During the 1990s startups and gazelles within knowledge- and technology-based sectors of the economy were the primary engine of job growth. New businesses and gazelles – companies growing at over 20 percent a year over a four-year period – accounted for 80 percent of net employment growth from 1992 to 1996 And knowledge economy sectors are expected to generate nearly three times more jobs than the older industries, growing 3.6 percent each year from now through 2008.



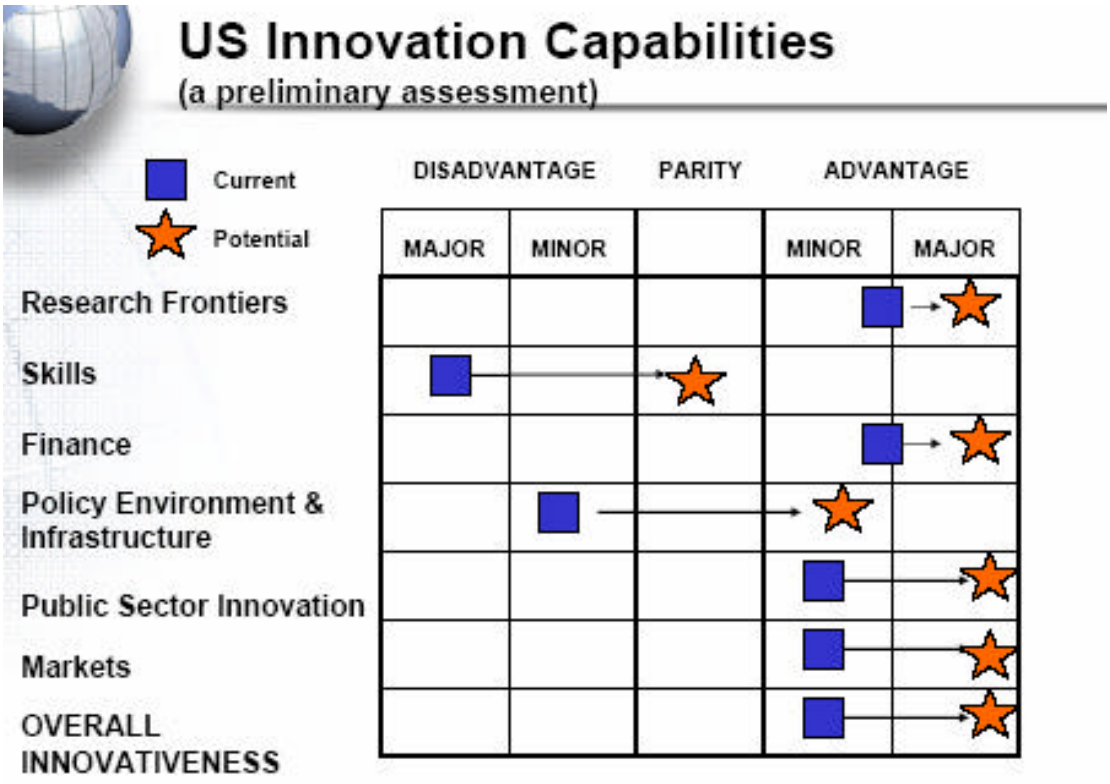
Innovation Metrics

Another key aspect of the new innovation ecosystem is measurement. If you can't measure something ... you can't drive it. It's clear that a myriad of measurements exist for economic indicators, but there's no single integrated database to give us a look at the economy through a new lens --- the lens of innovation. Government and the private sector, working on an international basis, must step up work on defining the metrics most appropriate for the new innovation economy.



Overall Innovation Assessment

Based on a qualitative synthesis of metrics available to the Working Group, we have concluded that overall the US is the world innovation leader. The strongest capabilities are the US investment in the frontiers of research and financial capacity. It also maintains a leadership position in public sector innovation, the size of its national market and a substantial competitive position in global markets. The areas of major concern and longer term weakness are in the areas of innovation skills, the policy environment and the infrastructure which supports the innovation process.



Strategic Policy Implications

To strengthen overall US innovation performance the following are strategically important national goals:

- Maintaining global leadership in scientific frontiers and emerging technologies.
- Fundamentally retooling human capabilities to learn, upgrade skills and adapt to global workforce dynamics.
- Implementing fiscal/ monetary policies to ensure an adequate supply of "innovation risk capital" and the incentive for rapid commercialization and diffusion.
- Elevating the innovation agenda, removing policy barriers to innovation and accelerating investment in supporting infrastructure.
- Modernizing government services through innovation.
- Expanding global markets for innovation.

6. General Principles for Innovation Policy

Today's de facto policy framework for innovation is obsolete and needs to be updated to reflect the emerging realities of global innovation. The Working Group believes certain general principles must be kept in mind as the NII formulates its recommendations:

- Private sector has the central role in transforming knowledge/technology into products, services and processes that meet the test of world markets.
- Government sets an overall economic environment and also impacts innovation as an enabler, facilitator, rule setter, international commerce negotiator, etc.
- Innovation policy should build on our strengths and minimize our weaknesses.
- Innovation policies should be balanced with respect to inputs as well as outputs.
- Research and technology inputs are necessary but insufficient for innovation success. Demand (market signals) can induce and accelerate innovative outputs. NII should examine policy approaches that enlarge the *markets* for innovation (e.g. market access, open competition in monopolistic/regulated markets, standards, intellectual property protection, technology investment incentives for users, etc.
- Modernization of our innovation policy framework requires *public and private leadership and the participation of broad array of stakeholders.* .

Innovation Stakeholders

The framework suggested by the 21st Working Group has important implications for stakeholders. The Innovation Economy is not the responsibility of any single organization or group of individuals. Maintaining innovation leadership, bolstering our technological, human and financial resources and ensuring a positive investment climate for innovation is the obligation of every citizen, every worker, every company, every educator and every policy maker.

The following section presents the action recommendations of the Working Group.

7. Recommendations for Action

Recommendation #1
Elevating Innovation as a National Priority

RECOMMENDATION

Innovation should be embraced by the President as a fundamental national objective and a crucial issue for US economic leadership, competitiveness and prosperity. The 21st Century Working Group's recommendations to address this important objective include:

1. **Establish through Presidential directives a Cabinet level interagency mechanism to strategically frame, assess, and coordinate the future direction of the nation's innovation policies.**

2. **Develop in partnership with the private sector innovation metrics, models and policy frameworks that better reflect the global, knowledge based, networked economy.**

3. **Promote public understanding of the benefits of innovation.**

Background Analysis

Each of these areas is discussed below with Working Group findings and more detailed recommendations.

1. Establish through presidential directive a cabinet level interagency mechanism to strategically frame, assess, and coordinate the future direction of the nation's innovation policies.

The public policy environment both lays the foundation in which innovation systems develop and is fundamental for economic growth. Innovation requires changes in the strategic thinking, education, systems and organization. It requires adaptation, including new tactics, new organizational constructs, and new means of communicating. The national policies we implement significantly affect innovation. The United States needs a public policy strategy which integrates the many aspects of the innovation equation. There is no single indicator, or policy choice, which will drive national innovation performance. A range of policies is required across many issue areas and many agencies and disciplines. Policy choices should be made with the clear outcome of driving innovation and economic growth in focus.

The 21st Century Work Group has evolved a comprehensive perspective on the nation's innovation system. Traditionally, innovation policy has focused on inputs in terms of research and invention, and in terms of training scientists and engineers. Today, we must think beyond these inputs and approach innovation in terms of customer value creation.

Policy makers and the general electorate may find it difficult to foresee the marketplace and needs that become apparent only as innovation occurs. Thus, a highly aware and educated population needs to understand the importance of adapting policies to the changing needs/directions in technology and innovation. Removing barriers to innovation is an important supplement to constructing strategies and policy. Institutionalizing "flexibility" is a challenge we need to address.

There is a clear distinction between innovation at the firm, institution or organizational level, and innovation as part of a national strategy. Both are critical to economic growth, but they can be confused. The focus of the National Innovation Initiative is developing a national agenda and strategy. As a result, our challenge as a nation is to look at the broad array of policies, across the board --- from taxes to market access – from technology partnerships to innovation financing --and to make that examination from the perspective of driving innovation. Then we must lay out clear, actionable, strategic policy choices for our society, with all the stakeholders at the table, with innovation at the core, and choose actions that will drive prosperity for our nation.

Detailed Recommendation

Innovation policy is the new competitive weapon for advanced industrial nations. The 21st Century Innovation Working Group recommends an aggressive public policy strategy that energizes the environment for innovation. We recommend that the President give consideration to following action items:

- ***Direct his National Security and Economic Advisors to rapidly to analyze current national security and economic policies and identify opportunities for immediate improvement in our innovation capabilities.***
- ***Engage his cabinet officers and direct them to undertake a policy, program and budget review and propose initiatives designed to foster innovation within each department and across all of them. Use this as an opportunity to break down some stovepipes and foster closer collaboration among the agencies.***
- ***Task PCAST and OSTP with an expedited review of federal science and technology research and development policies and programs to identify immediate and long-range opportunities to strengthen the federally funded base of the national innovation system.***

Benefits of Recommendations

Creating a national agenda across the multiple issues and stakeholders which is explicitly based on innovation will create a more informed and data driven policy agenda.

2. Develop in partnership with the private sector innovation metrics, models and policy frameworks that better reflect the global, knowledge based networked economy.

Economic studies during the past several decades have concluded that technology innovation (and related capital and human investment) contributes nearly half of the nation's productivity, economic growth and standard of living. It is thus imperative that

government and business leadership pay the utmost attention to the role of innovation in US growth, competitiveness and quality of life. Sound policy analysis and decision-making requires credible, timely and relevant measurements. "What you get is what you measure." Bad metrics can lead to bad diagnosis, which in turn results in bad or poorly designed policies with unintended consequences.

Innovation is a complex and multidimensional activity that cannot be measured directly or with a single indicator. The drive for improved indicators stems from the understanding that currently available measurements largely reflect the industrial era and less so the knowledge economy unfolding around us: they largely reflect products and artifacts rather than ideas and processes. An up to date view requires more attention to the demand for innovation, customer value creation and global markets--and to related determinants such as knowledge process flows, interfirm linkages, government policy environment and the infrastructure for innovation (*Innovation Framework Report, Milbergs)*. Such a multi-dimensional view will assist policymakers understand the dynamics of innovation, surface policy implications and better inform those who must make decisions impacting the innovation process.

The 21st Century Working Group calls for an aggressive government wide effort, coordinated internationally, to develop innovation metrics that look beyond innovation inputs and toward outcomes, as well as, and quite importantly, innovation processes. This initiative should be holistically framed and managed across government statistical agencies and coordinated extensively with international organizations that are addressing the next generation of innovation indicators, including metrics for market demand, public policy impact, networks and infrastructures and methods for managing innovation.

An expanded set of publicly available innovation metrics will enhance the utility of major analytic tools for assessing innovation behavior:

- **Growth Accounting**—economists will be able to better estimate the nation's productivity performance in terms of contributing factors and outputs.
- **Knowledge Economy**—composite knowledge indicators will improve investment decisions for R&D, education and capital resources.
- **Financial Reporting—**financial reports could provide a balanced scorecard of physical as well as intangible assets.
- **Valuation of Innovation**—business executives and financial markets could better value R&D activity, estimate financial results and predict outcomes.
- **System Dynamics**—expanding the range of "real-time" innovation metrics would help build more robust systems dynamics models and policy simulations. .
- **General Purpose Technology (GPT)** — improved analysis of the dynamics of GPTs which set the stage for incremental innovation and have the inherent potential for pervasive application in a wide variety of industries.
- **Tech-led Regional Development and Clusters**—shift the emphasis from strengthening inputs to regional innovation infrastructures toward improving the efficiency, rate and output of innovation.

Firm Level Metrics

As important as metrics for innovation at the national level, firms must also assess the rate of adoption and creation of innovation within their own cultures. There is, however, no simple formula for that measurement. Rather, there are a number of variables that, when considered in the following context can yield some insight into a firm's progress:
Invention + Insight+ Exploitation = Innovation

Invention in this view is a key input, requiring creation. Invention can be measured in a number of familiar ways, the # of patents and amount of intellectual property being the most obvious. To be a factor, invention must lend itself to insight, adding value to a customer's process. This factor can not be executed without a supportive culture. Finally, innovation can not occur without exploitation.

Exploitation/implementation is value appropriation. Individuals or entities engage in innovative activities that create value for one of three broad groups: economic profits (innovating individual or firm), consumer surplus (the economic term for the value that accrues to customers) and imitation or development cost savings (which accrue to other firms, including competitors and non competitors).

When developing metrics it is important to avoid potential "fatal flaws," such as: development of too many metrics and the resulting over-reporting that crowds out innovation; inappropriate metrics that "punish the innocent" vs. stimulating innovation; extreme focus on immediate outcomes; overemphasizing cost cutting v. value creation; and lack of a clearly defined innovation program. *(Adapted from Five Fatal Flaws of Innovation Metrics, Thomas D. Kuczmarski, Marketing Management, Vol. 10, No. 1, Spring, 2001*).

Detailed Recommendations

In order to support effective innovation policies, the Federal government in partnership with the private sector should urgently develop innovation metrics, models and policy frameworks that better reflect the global, knowledge based, networked economy. The Working Group further recommends that metrics be developed for application at the firm level to predict and manage the risks/benefits of research investment and product development lifecycles. Relevant and timely innovation metrics enhance public understanding and improve policymaking and continue to ensure that the US is the most fertile and attractive environment for innovation in the world.

Benefits of the Recommendations

- Establish the case and importance of the National Innovation Initiative.
- Enable deeper understanding of the complex phenomenon of innovation, which has been severely constrained on the empirical side due to the lack of appropriate metrics of the networked, knowledge economy at all levels.
- Improve innovation policy as a driver of economic growth, standard of living, employment and business competitiveness.
- Benchmark US innovation performance regionally and internationally
- Signal emerging opportunities and threats.

- Improve innovation management, tracking tools, investment analysis and risk assessment.
- Establish accountability and evaluation criteria, especially for government programs.
- Expand public awareness and understanding of the role of innovation.
- Measure firm level innovation progress, risk and results.

3. Promote public understanding of the benefits of innovation.

Americans are expressing a great deal of uncertainty about the economy -- uncertainty that is much more pronounced than a few years ago. Many factors have contributed to this sentiment: the war in Iraq, the dot-com bust and ensuing economic recession, widespread layoffs that are impacting both blue and white collar workers, and the outsourcing of jobs to foreign countries. As a result, there is a tremendous concern about losing personal control, longer working hours with fewer rewards, and dislocation of jobs.

Given this current environment, it is not difficult to see that the topic of "innovation" is not only deemed by the public to be not critical – it is even considered a threat to the American way of life due to its association with offshoring jobs that would have otherwise remained in this country. Additionally, there is a real sense that American workers are on the losing end of the emergence of a "global economy." Importantly, people are not comfortable talking about a world without borders. It presents both economic and national security (post-9/11) concerns.

In addressing public attitudes critical to innovation we must be very sensitive to these feelings of insecurity. The President and members of his Administration have extensive access to the media and the public. The Administration should use this access to explain the extraordinary range of innovation opportunities and address the public's anxieties about the challenges that lie ahead. With adequate explanation, foresight and understanding public attitudes will become more adaptive to the requirements of an economy driven by innovation and continuous change in how we work, live and play.

Detailed Recommendation

Working in partnership with the nation's innovation stakeholders, the Administration should launch a multi-faceted outreach program to expand public understanding of the benefits of innovation. The outreach program should be aimed at unleashing a wave of creative potential that is inclusive of all economic, government and social sectors and tie innovation inextricably into perceptions of enhanced U.S. competitiveness, maintaining U.S. leadership and creating more U.S. jobs.

Benefits of the Recommendations

- Broader acceptance of innovation initiatives in public policy
- Heightened awareness of need to improve US innovativeness
- Stimulate innovation and creativity across the board.

Recommendation #2
Retooling Skills for Innovation

RECOMMENDATION

Education, both at the college level and in K-12, needs significant changes to prepare students to be leaders and innovators in the coming years. The system needs to be re-aligned to promote a competitive, 21st century definition of student achievement. One essential target for reform is in the area of curriculum, where creative and integrative instruction based on Problem-Based Learning (PBL) should be developed and implemented within multi-disciplinary and diverse teams, including distributed teams where possible. Additionally, Standardized Technology Platform(s) to support PBL using interchangeable course modules should be developed and deployed to solve the scalability, and complex course management issues that PBL raises. New methods of teacher training, school organization, governance, incentives and accountability must also be addressed to support and sustain the newly-aligned system.

Background Analysis

The workforce of the future requires people who have the following types of skills: strong communication skills, ability to work collaboratively, ability to manage ambiguity, strong problem solving skills, and the ability to rapidly learn new skills. A system that is designed to support curriculum that focuses on acquiring discreet skills and memorizing information will not generate the leaders and innovators we need. Given our current education culture, vertically organized curricula, and accountability targets changes are required in all levels of education, i.e., K-12, College and Corporate. If we are to prepare the nation to compete we must nurture these skills that have a direct impact on our nation's role as a technical and innovative leader. Significant growth in US productivity over the last 5 years has occurred *despite* the fall in work-force educational skills. However, in the longer term, this lack of investment in the appropriate skills will be a threat to our economic stability and national security. [1] [2]

Problem based learning (PBL) is one methodology which appears to be able to help enhance the development of these badly needed skills. Viewed as an effective approach to developing scientific, mathematical and technological talent and creativity, PBL focuses on ill-structured problem solving, providing more meaning, applicability and relevancy to classroom materials and facilitating the development of critical analysis skills that are needed in the workplace. [8,9,10] According to Andrew Hargadon's hypothesis on driving technology innovation, "It is one thing to know about a technology; it's something different to know how to apply it, what else it can do, and how to adapt it to new settings. Those skills come only through use, if only just once or twice." This being the case, problem-based learning helps foster an innovative environment by encouraging students to

[1] How to use problem-based learning in the classroom, Robert Delisle, 1997.
[2] Learning for the 21st Century, Partnership for 21st Century Skills Org, 2003
[8] Do as I say, not as I do? Student assessment in Problem Based Learning, Jeff Nowak and Jonathan Plucker, Indiana University, June 1999.
[9] Integrating the Core Business Curriculum: An Experienced-Based Solution, Larry Michaelsen, Selections, 2001, 9-17
[10] The Case against Teaching: Larry Spence. Change, New Rochelle Press, Nov/Dec 2001 1-1

extrapolate learning from other experiences and applying them to solving a problem at hand.

Key characteristics of PBL include: Ill-structured, complex problems that provide the focal points and stimuli for the course or ideas originated by students that can be developed during the learning process; Learning is student-centered with teachers acting primarily in the role of facilitators; Faculty act as a coach or facilitator as students assume greater responsibility for their own learning; and students work in small groups to solve/provide multiple solutions to problems.

- PBL requires significant changes in culture, policy, and organization of schools for effective implementation – a re-alignment of the entire enterprise to focus on new goals.
- Curriculum reform can not proceed without significant changes in teacher preparation, professional development, incentives
- Education accountability must focus on metrics and use assessments that are aligned with PBL and the new skill set required for the new workplace

While PBL helps to foster key skills needed in the workplace it should be noted that the workplace is no longer a local environment but a global environment. Hence it is necessary that students be exposed to collaborative technologies that facilitate interactions among students at geographically different locations. Such technologies should be used with PBL, such that the teams are composed of students at different locations. The costs of having these technologies easily available at all sites must also be considered with the implementation of the proposed curriculum. Just as the workplace will, by definition, continue to evolve in the future, schools must become enterprises that support innovation and encourage the development and implementation of new curriculum and approaches.

Benefits of the Recommendations

Beneficial for all levels of education, PBL and similar methodologies will help enhance current curricula and build much needed skills in both incumbent workers and ensuing generations. In addition to fostering students' motivation to learn other disciplines, students will gain an appreciation for life-long learning. Further, the interactions result in better communication skills as students relate their specific knowledge to others to solve a common problem. Creative, integrative curricula will develop these critical skills, enabling the US to compete more effectively and become more innovative and will provide the population to leverage these skills to move up the economic value chain. Schools can become the place where students encounter an environment that supports, encourages and responds to innovation.

Recommendation # 3
Catalyzing Investments in Innovation

RECOMMENDATION

Innovation requires research investment and collaboration between many parties, including large, medium and small companies, universities, and government. Collaborative arrangements can result in higher innovation productivity. Effective collaboration demands new mechanisms. The 21st Century Working Group's recommendations in this area include:

1. **Strengthen knowledge networks between appropriate partners, both virtual and real by establishing a National Innovation Portal, an open-source forum for innovation that matches companies with appropriate partners.**
2. **Enhance federal and state funding for research and innovation, especially merit-based programs (cf. NSF, NIH, DOD, DOE, DOC, and state programs) that match or provide funding in all technology areas according to technological and commercial promise.**

Background Analysis

Each of these areas is discussed below with Working Group findings and more detailed recommendations.

1. Foster stronger collaboration of government, public, companies and universities for the creation of collaborative networks capable of spreading the risks of failure and enriching the sources of knowledge for innovation.

Collaborative arrangements, both on-line and in-person, can result in higher innovation productivity, economic growth and standards of living. Inter-organizational collaboration can allow corporations to reduce innovation and market risks, facilitate the movement of human capital across geographic boundaries, and mitigate the inevitable adjustments of currency and production capacity. The high risks of innovation used to mean that only very large corporations could afford to undertake large, multi-year projects. However, new communication technologies and a deeper understanding of how innovation can be managed across boundaries (interpersonal, interdepartmental, inter-organizational, and international) make it now desirable to innovate collaboratively.

Thus, the state-of-the-art in managing innovation is the creation of collaborative networks capable of spreading the risks of failure and enriching the sources of knowledge for innovation. These collaborative arrangements can range from dyadic partnership to virtual organizational networks, defined as clusters of organizations, bound by common objectives, broadly compatible technology platforms, and organizing principles such as language, dispute resolution processes, and information sharing protocols.

Industry Clusters are networks of enterprises, large and small and they may also encompass universities. Each member adds a distinct product or service value, which is then added to the value of the (local) network as a whole. Currently, funding for the development and encouragement of Industry Clusters is a jurisdictional effort, intended to culture local new businesses with resulting tax revenues. While individual jurisdictions allocate funds to the creation of clusters, they require an appropriate combination of resources and an impetus, a spark, to begin. Allocating funds does not ensure one will emerge, nor is a spark without resources sufficient. Once in motion, clusters can take years to build momentum, and once they do, they are subject to limitation by the very resources that spawned them.

To date the focus of the cluster innovation has been spatial proximity. Spatial proximity builds social capital, which is the primary source of trust. All collaboration and innovation rests on this trust. Telecommunications technology continually improves the ability of companies to collaborate with resources outside funded jurisdictions. If a level of trust can be established without the need for spatial proximity, through the use of communications technology, the speed of innovation can be further increased.

Companies need a new means of looking outward. This can be greatly accelerated by using emerging Virtual Knowledge Networks. Such endeavors are already underway in Europe, making use of centralized server and peer-to-peer models.[3] The creation of a Virtual Knowledge Network, leveraging communications technology to facilitate the matching of needs for innovation with those who can best provide it, will allow companies of all sizes and in Clusters to sustain their competitive strengths.

The features of such virtual networks would include: access limited to registered US enterprises; build virtual teams with security and established trust procedures; procedures for managing shared intellectual property; proven innovation management software; and, problem/opportunity driven rather than transaction focused. Because collaboration will occur across regional boundaries, offering opportunities to many jurisdictions, funding must be offered at the Federal level to ensure the maximum utility of the Network. Beneficiaries of continual innovation include companies and entrepreneurs who profit by it, employees who operate said companies, and the jurisdictions to which they pay taxes. Money generated and spent in a community improves the quality of life for all residents.

Detailed Recommendation

Establish a National Innovation Portal, an open-source forum for innovation that matches companies with appropriate partners, initially for small and medium-sized enterprises. Going beyond a jurisdictional and local Industry Cluster focus (state, city, townships, and counties) on innovation investments would expand opportunities to engage more companies in other areas and encourage a broader range of innovation.

Benefits of Recommendations

Collaborations increase the speed of innovation, provide access to innovation resources, especially for SMEs, and support cluster, regional and national competitiveness.

[3] Passiante, et al. Digital Innovation. Imperial College Press, London. 2003.

2. Enhance federal and state funding for research and innovation, especially merit-based programs (cf. NSF, NIH, DOD, DOE, DOC, and state programs) that match or provide funding in all technology areas according to technological and commercial promise.

Competition in products varies along a spectrum. At one end of the spectrum are products in which a few firms become dominant producers of a product, and late entrants rarely if ever capture substantial market share. In the middle of the spectrum, early and late entrants perform similarly; early and late entrants have similar rates of growth and similar rates of abandoning the market. At the other end of the spectrum are products (or time periods for specific products) in which late entrants have unusual opportunities to take over markets from incumbent firms and new firms are likely to become market leaders. The first two types of products have been shown to be common. The third type definitely occurs but its relative frequency is unknown and, from the little research available, appears to be modest.

These competitive processes matter for international competitiveness, because they affect US firms' ability to stay in, or enter successfully, the business of producing any given product. Being one of the relatively early firms to produce a new product, especially in the first type of industry, is (on average) a route to profit and employment. Late entry by US producers is most likely to succeed in the second and especially third type of industry. Loss of firms' competitive edge in the first type of industry is likely to be difficult or impossible to reverse.

Although it is tempting to target efforts to help industries that are ailing in the face of international competition, it is far from clear that such help has had any net benefit. R&D funds may be too little too late, so that US firms fail anyway as they cannot match the quality and efficiency of international competitors. For example, targeted R&D and small business funds may be awarded to the most promising projects, where part of what makes for promise is the ability to become and remain competitive with other firms in the industry. Trade restrictions, through tariffs, anti-dumping laws, and other means, are often assessed as having society-wide costs that exceed the benefits.

Another consideration for policy is that large firms appear to have the advantage for incremental, routine innovation. Small and large firms appear to be more similar in their ability to create new products, radically new technological approaches, and innovations for which marketable patent rights are unusually defensible. Although it is often argued that small firms have the advantage at creating novel innovative approaches, research has attained no definitive conclusion on this issue and any difference appears to be modest or perhaps nonexistent. Hence large firms are important to retain national competitiveness in many industries, and large firms operate roughly as effectively as small firms in other industries. Competition appears, from the (limited) existing evidence, to spur innovation in that the most innovation seems to occur when 2-3 firms operate in a market instead of a single monopolist (and instead of many small firms but that may depend on type of industry).

Innovation appears to be the major reason behind the above competitive outcomes. That is, if firms establish themselves as long-term market leaders in an industry it is likely that innovation was the cause of their success. Likewise, if firms take over the leading market share from incumbent firms in an industry it is likely that they gained this dominance through innovation. Innovation includes not just major new products or methods, but also vast numbers of minor improvements to the nature of a product or service or to how it is manufactured or provided. Large numbers of minor improvements appear to be crucial in the first type of industry, whereas more radical changes appear to be key in the third type of industry.

How do these characteristics of innovation relate to the appropriate kinds and amounts of corporate and government spending? The kind of innovation that is most useful is where the greatest opportunities lie, including service products. Since services now constitute the bulk of GDP, innovative development that promises broad-based improvement in services may be especially fruitful. Kinds of innovation in which government investment may be especially fruitful include more basic research and development, outside the often short-term planning horizons of businesses. Indeed businesses may need to consider longer time horizons in their budgeting of R&D and innovation given that their global competitors may do the same. The amount of R&D investment that should ideally be made, as a percentage of GDP, is difficult to assess. However innovation (and the subsequent transfer of innovative results and skills) is the primary driver of economic growth, and maintains the nation's economic viability in an age of international market competition. Assessments have indicated that the benefits of publicly subsidized R&D and innovation far outweigh the costs.

Benefits of the Recommendations

- Help the nation's companies to remain competitive
- Facilitate job retention or growth, instead of job loss to high-quality, high-efficiency foreign firms
- Retain strong value in US investments including retirement plans
- Retain one of the world's leading technology and innovation infrastructure
- Enhance development of new products, improve product quality and features, and enhance efficiency, yielding greater economic growth

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- *Executive Briefing Report: Innovation Metrics, January, 2004*
- *Innovation Metrics: Measurement to Insight, 4/28/04 presentation to 21st Century Working Group*
- *Extensive array of innovation reports and indicators by NSF, World Economic Forum, OECD, European Commission, etc...posted to the NII Web Portal www.compete.org*

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