SMART PROSPERITY

An Agenda for Enhancing Productivity Growth

June 2000

A NACFAM White Paper

NACFAM

National Coalition for Advanced Manufacturing

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Foreword

We are optimistic about the nation's future. The twin challenges of the past two decades – the ideological and military struggle with communism and the economic competitiveness crisis of the 1980s – are behind us. The challenge we face today is to avoid complacency. The economy is booming and all the economic indicators point the right way.

However, these trends are not immortal and we are at a critical juncture. The danger is that we will stop doing what it took to get us here in the first place. That we will stop investing in the infrastructure for productivity-driven growth – the bedrock of the "New Economy." We did this in agriculture over the past century or more through the successful collaboration of government, universities, industry, agricultural extension centers, individual farmers, and their associations. Surely, we can find ways to do the same thing for manufacturing today.

We believe the complacency challenge is one we can avoid by making "smart" decisions. With the proper perspective and patience, we can take the necessary steps today to expand prosperity in the future, so our children and grandchildren can enjoy a consistently rising standard of living, just as we have, and so this great nation can afford to address its many needs for constant improvement.

To address this question, the National Coalition for Advanced Manufacturing (NACFAM) created the Advanced Manufacturing Leadership Forum (AMLF), comprised of leaders from the private sector, academia, and government, to identify steps the nation could take today. Over the past year-and-a-half this group conscientiously considered the fundamental factors behind our current economic boom and developed thoughtful steps on how to proceed.

Their conclusions are reflected in this paper, *Smart Prosperity: An Agenda for Enhancing Productivity Growth*. This paper proposes some first steps in a long journey ahead. However, identifying what should be done is not the same as having it be done. Therefore, we believe this Agenda represents the beginning of a nationwide dialogue on the economic future of the United States and the responsibilities of industrialists, labor, educators, and public officials in expanding this prosperity.

We want to thank the participants in the Advanced Manufacturing Leadership Forum and many others for their efforts. Their insights were invaluable and they should be commended for their foresight and creativity.

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Executive Summary

The United States is currently enjoying a period of unparalleled prosperity. Economic growth is rising, productivity is soaring, unemployment rates are low, and optimism is abundant. The potential for even greater prosperity is within reach. By making the "smart" decisions today, the U.S. will position itself to benefit from sustained economic growth well into the 21st century.

The question for business leaders, workers, academicians, and policy makers is not whether this prosperity can continue, but what can be done to ensure that it does. Investments made today in the infrastructure supporting manufacturing will lay a foundation for increased economic prosperity well into the future. Government, both state and federal, industry, workers, labor unions, the education community, associations, and other groups share responsibility for maintaining this infrastructure.

In the last five years, productivity improvement by U.S. manufacturers leads the nation, raising profits and wages for individual firms and workers, and allowing the national economy to maintain low unemployment, low interest rates, and increasing standards of living. Manufacturing is transforming, moving from a factory-centric operation to an extended production enterprise including production and assembly, but also design, distribution, and integration. The system is highly distributive, flexible, and global. This transformation is on-going, but the evidence is clear – the productivity of the manufacturing sector is driving the U.S. economy toward greater prosperity.

The National Coalition for Advanced Manufacturing (NACFAM) created the Advanced Manufacturing Leadership Forum (AMLF) in March 1999 to bring together business, academic, and civic leaders as well as state and federal government officials from around the country to develop a national agenda to enhance productivity growth in the manufacturing sector. The AMLF considered the core components of economic growth and recommended specific initiatives to:

- Guarantee the continued health and vitality of the research and technical infrastructure, which has been so instrumental in fueling the current expansion, by increasing the federal commitment to research in the engineering and physical sciences, with an emphasis on basic manufacturing science and technology;
- Encourage collaborative R&D partnerships among industry, universities, federal laboratories, and other research institutions to expand the private sector's commitment to longer-term, higher-risk research and stimulate the development of productive partnerships among these organizations through state tax credits for collaborative research or other mechanisms to promote collaboration;
- Increase the skills of American workers, enhance skills portability, and better align education with workplace needs by building a nationwide system of skill standards, assessment, and certification;
- Overcome the shortage of skilled workers and assist workers in updating their skills through two federal technical training tax credits covering both entry-level and incumbent workers;
- Accelerate the use of advanced technologies and techniques by small- and medium-sized manufacturers by expanding, refocusing, and leveraging manufacturing extension services;
- Overcome software interoperability problems that plague small and large manufacturers and cost the economy billions each year by stimulating voluntary open standards for e-manufacturing.

These and other similar ideas should move to the forefront of public policy. As the U.S. prepares to elect a President and Congress for the beginning of the new Millennium, policymakers must recognize the opportunities and adopt smart measures to secure an era of strong productivity growth.

Introduction

Prosperity raises a new set of challenges for the United States. The conditions that brought about the current economic environment are not the result of one person's or one group's effort. They are the product of smart decisions by individuals, firms, and governments. Good decisions made the present possible. Smart decisions today will make it possible for the present prosperity to continue and expand. Therefore, the important question for the United States today is not when the current economic expansion will end, but what must be done to keep the economy growing?

In today's economy, productivity is the catalyst for economic growth. In typical business cycles, productivity slows as the expansion matures. Exactly the opposite is occurring today. Led by the technology-intensive manufacturing sector, productivity is posting ever higher growth rates. Productivity, of course, is the aggregation of actions taken by individual workers and companies to produce products more efficiently at lower cost. The combination of high efficiency and low cost produces a dynamic mix. A high productivity economy can grow with low rates of inflation and unemployment, rising wages, and increasing profits.

As the U.S. proceeds into the 21st century, pressing national and international problems loom on the horizon. Whether we can address these problems without sacrificing the standard of living for ordinary Americans rests on the choices made today. Confronting these problems will not be easy and demands significant resource commitments by the nation. The only strategy that can reconcile the competing goals of growing the standard of living and overcoming these problems is for the economy to continue growing and expanding as it is now. A growing economy increases the options and opportunities for all. In a $10 trillion economy, increasing the rate of growth by 1 percentage point adds an additional $100 billion in just the first year. The effect of such an increase is cumulative. Those funds are reinvested and used productively by others, thereby, generating additional wealth. Estimates suggest the compounding impact of a one percentage point jump in growth is nearly $4 trillion over 10 years. Accelerating productivity growth raises the possibility of altering growth rates by more than 1 percentage point with the associated benefits.

Securing wealth creation in the 21st Century should thus be a major public policy concern. Choices must be built on a foundation of knowledge and understanding of the factors driving productivity growth.

To help assess these factors, NACFAM undertook a Productivity Research Series in the fall of 1998. Following a period of intensive research and expert workshops, NACFAM then formed the Advanced Manufacturing Leadership Forum in March 1999 as its public policy arm to develop policy proposals based upon this research. The AMLF organized high-level Forum meetings for this purpose, beginning with an AMLF meeting on Capitol Hill in April 1999 hosted by Senator Abraham (R-MI), who challenged NACFAM to bring industry-led proposals for strengthening the U.S. manufacturing base back to his Senate Subcommittee on Manufacturing and Competitiveness.

Regional meetings were held in Chicago, Detroit, and Palo Alto between October 1999 and February 2000. These meetings brought together local business leaders, representatives of universities and community colleges, state and local economic development officials, as well as other interested parties to develop and discuss a set of policy proposals. The meetings were highly successful in identifying factors driving productivity, assessing strategies and policy proposals necessary for sustaining that productivity, and beginning the process of building a national consensus in support of action in these areas.

In March 2000, the views and opinions of a nationwide audience were solicited at NACFAM's annual public policy conference in Washington, D.C. The conference was the culmination of the AMLF's regional strategy. By bringing a national audience together to consider these issues, NACFAM was able to validate the national level of support for the policy proposals. Participants focused on refining and strengthening the policy proposals. Members of Congress, Administration officials, and their staff, offered assessments as well. The outcome was an enormous amount of feedback that reinforced certain elements of the proposals and outlined important areas of improvement for others.

From the very beginning, the AMLF process represented a new way of thinking about policymaking. By focusing on regional meetings, the AMLF tested and built its policy recommendations through dialogue and consensus with organizations and individuals with very different views of productivity growth and manufacturing. Although the AMLF met in regional groups, the purpose was clearly the identification of national solutions to problems shared by manufacturers of all types.

"You can't have smart prosperity without a government that allows you to be smart."

The Honorable Andrew Card
GM Vice President and Former Secretary of Transportation

The result of this process is an agenda that is an interesting mix of policy proposals that reflect of the attitudes of AMLF participants. The individuals who participated do not want, nor expect, federal or state government to provide specific answers to the problems they face. Rather, they want government to work with industry and education to remove obstacles and provide the tools and underlying infrastructure to allow them to solve their own problems. The attitude was one of empowerment and independence, yet collaboration, and the agenda reflects that.

The AMLF considered three large topical areas of public policy that were considered critical determinants of the future productivity of the manufacturing sector – (1) National Research Investment; (2) Workforce Skills Development; and (3) Enhancing the Performance of the Small- and Medium-Sized Enterprise (SME) Supply Chains. Within each of these areas, two major proposals were developed. The policy recommendations represent first steps in the development of a broad strategy to continue productivity growth and economic prosperity.[1] The AMLF recognizes the challenge of "smart" prosperity is an ongoing one. Additional steps are needed and other issues must be addressed. Still, the time to act is now when times are good and resources are plentiful.

The proposals are described in greater detail following a discussion of the importance of productivity and the role of manufacturing in the 21st century economy.

[1] The focus was limited to two proposals in each area, not because the two were deemed sufficient to address the breadth of the issues, but to provide a manageable starting point for what will be an ongoing and cumulative policy development process.

The Importance of Productivity

The prosperous economic times currently being enjoyed in the United States are made possible by the sustained resurgence of productivity growth. The record length of the expansion, with consistently strong growth rates, low unemployment, and low inflation, confounds estimates and expectations because of surging productivity growth.[2] Productivity's importance extends beyond the simple measurement of economic efficiency. At its core, productivity is an indicator of a mix of actions on the part of businesses, workers, scientists, educators, and governments. Investments in technology and capital, effective use of available technologies and products, the skills and flexibility of the workforce, and management practices all together determine the productivity of a firm.

"Not only has the expansion achieved record length, but it has done so with economic growth far stronger than expected. Most remarkably, inflation has remained largely subdued in the face of labor markets tighter than any we have experienced in a generation. A key factor behind this extremely favorable performance has been the resurgence in productivity growth."

Alan Greenspan
Chairman, Federal Reserve

Productivity represents a pathway (Figure 1), along which technology, human skills, capital assets, and management techniques combine to influence the performance of individual plants, workers, and firms and then whole industries, regions, and finally the nation. From the firm's perspective, high productivity increases output without increasing costs, which allows it to pay higher wages without jeopardizing profitability. Resources are used more efficiently, product quality improves, and the company's market share expands. At the national level, a highly productive economy has lower interest rates, increasing standards of living, and low unemployment. Over time, compensation and productivity growth rates are closely linked (Figure 2). Together, these factors mean higher growth rates and expanding prosperity for the nation.

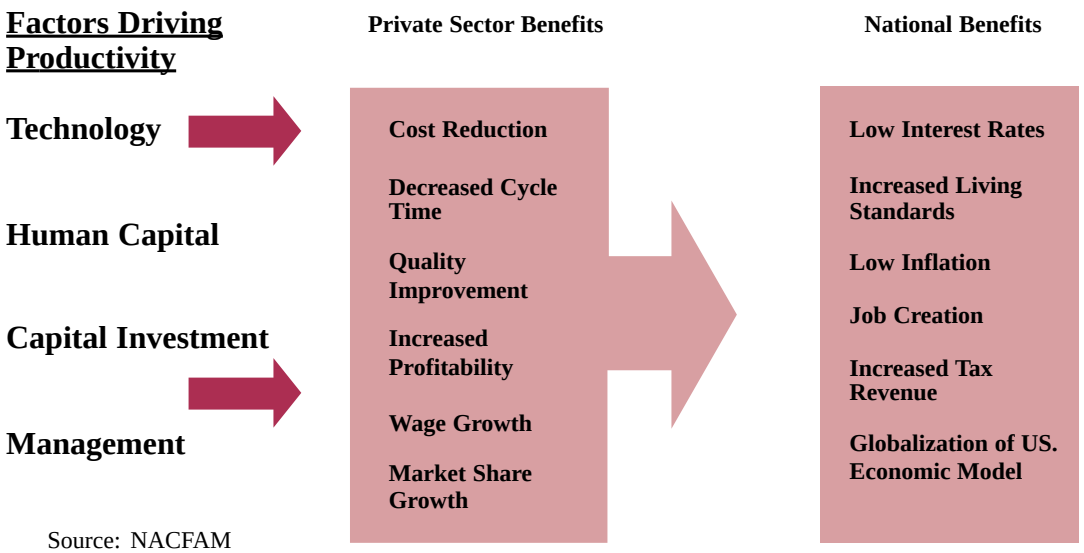
Measuring Productivity

In conventional terms, productivity of the economy is measured in one of two ways – labor or multifactor. Labor productivity is simply output per hour. According to the U.S. Bureau of Labor Statistics (BLS), "output, measured net of price change and inter-industry transactions, is compared to labor input, measured as hours at work in the corresponding sector." For multifactor productivity, on the other hand, "output is again measured net of price changes and inter-industry transactions, but the input measure is an aggregate of hours at work and capital service flows."

Both measures are subject to severe limitations that limit the ability to accurately gauge economic performance. Critics contend that labor productivity is too crude and simplistic and multifactor productivity takes too long to calculate. Multifactor estimates are preferred for their detail, but they can not provide the real-time data needed by businesses, economists, and policy makers. Labor productivity is much more responsive in that regard and hence, its wider use. The AMLF firmly believes greater attention should be paid to upgrading and modernizing national data collection systems and techniques to reflect the new features of the rapidly changing 21st century economy.

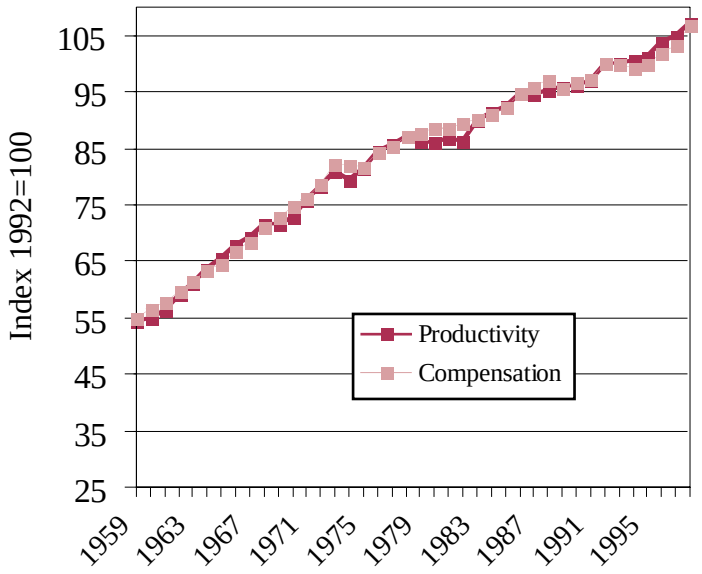
[2] In past expansions, productivity growth rates have been highest at the start of the expansion and then consistently declined. The current expansion (1991-1999) broke that trend. Beginning in the fifth year, productivity growth rates have climbed steadily. In fact, after year 7 of the current expansion, productivity growth actually surpassed the rate of the first two years. See Council of Economic Advisers, *Economic Report of the President*, (Government Printing Office: Washington, D.C., 2000): 34-35.

Figure 1: Productivity is a Pathway



Source: NACFAM

Figure 2: Compensation and Productivity Positively Linked



Period	Annual Average Change In Productivity	Compensation
1959-73	2.8%	2.9%
1973-90	1.0	1.0
1990-98	1.2	1.3

Source: Unpublished BLS data.

". . . [W]e believe that labor productivity growth can be maintained at a new, higher rate, which, in turn, will permit faster growth. We agree with those who think a 3 percent growth rate in GDP well into the future is within the realm of possibility."

Barry Bluestone and Bennett Harrison, Growing Prosperity

Greater productivity means the economy can grow much more rapidly without sacrificing sustainability. Many economic analysts believe growth of 3.5 percent is possible without risking inflation, up from 2.5 percent just a year ago. The one-percentage point difference is significant. In a $10 trillion economy, an extra percentage point of growth means an extra $100 billion to economy in the first year alone. The long-term effect is even more staggering. Compound growth rates cause the effect to cumulate over time, generating a massive impact on the economy. According to Barry Bluestone and Bennett Harrison, increasing the GDP growth rate by just 0.7 percent will generate $3.2 trillion in total real output between 1999 and 2008 on account of the compound effect.[3]

U.S. productivity growth has surged in the 1990s. Between 1973 and 1995, labor productivity for the nonfarm business sector increased at a rate of 1.4 percent a year. Since 1995, that rate has accelerated to 2.9 percent.[4] The change is even more pronounced in the technology-intensive manufacturing sector. Manufacturing productivity jumped 6.4 percent between 1998-1999, with an unprecedented fourth quarter increase of over 10 percent. Over the decade of the 1990s, manufacturing has clearly led the way for national productivity growth (Figure 3). Even using measures of multifactor productivity, manufacturing has shown remarkably steady growth through the early 1990s, peaking at 3.84 percent in 1995, according to the most recent data (Figure 4). Since 1950, manufacturing has posted a growth rate that high only three other times – in 1950, 1959, 1962.

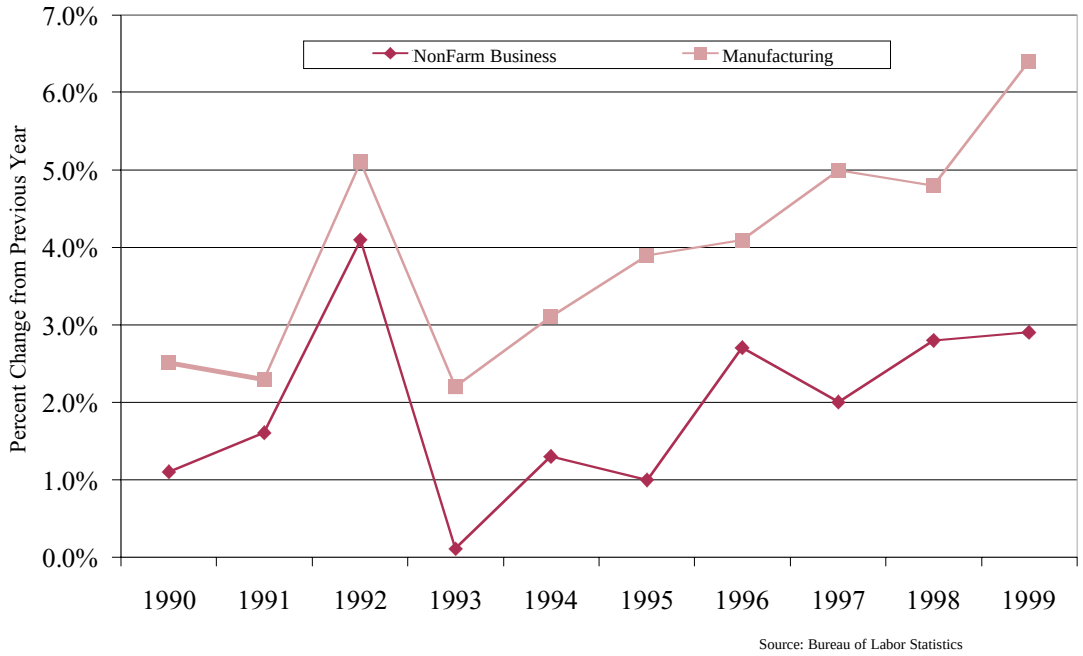
Despite this strong performance, these benefits are not shared equally. Computing and communications equipment manufacturers are enjoying phenomenal rates of productivity growth, 41.7 percentage points at an annual rate between 1995-1999, while other sectors have average or low growth rates.[5] Recent research suggests the computing sector accounts for the vast majority of manufacturing productivity growth. Differential rates of growth raise important concerns about future national prosperity. For instance, What happens if the Internet economy collapses? A "smart" reaction to such circumstances is not to bemoan the possibility of decline, but to think about ways to improve the performance of the other sectors. Imagine the impact on the economy if automobiles, aircraft, or textiles were able to match the performance of the computing sector in recent years. A prudent set of steps and policies, such as those outlined in this agenda, will lay the foundation for America's workers and manufacturers to help themselves respond and react to the changing economic environment.

[3] Barry Bluestone and Bennett Harrison, Growing Prosperity: The Battle for Growth with Equity in the 21st Century (Boston: Houghton Mifflin, 2000): 8.

[4] Council of Economic Advisers, *Economic Report of the President*, (Government Printing Office: Washington, D.C., 2000): 79.

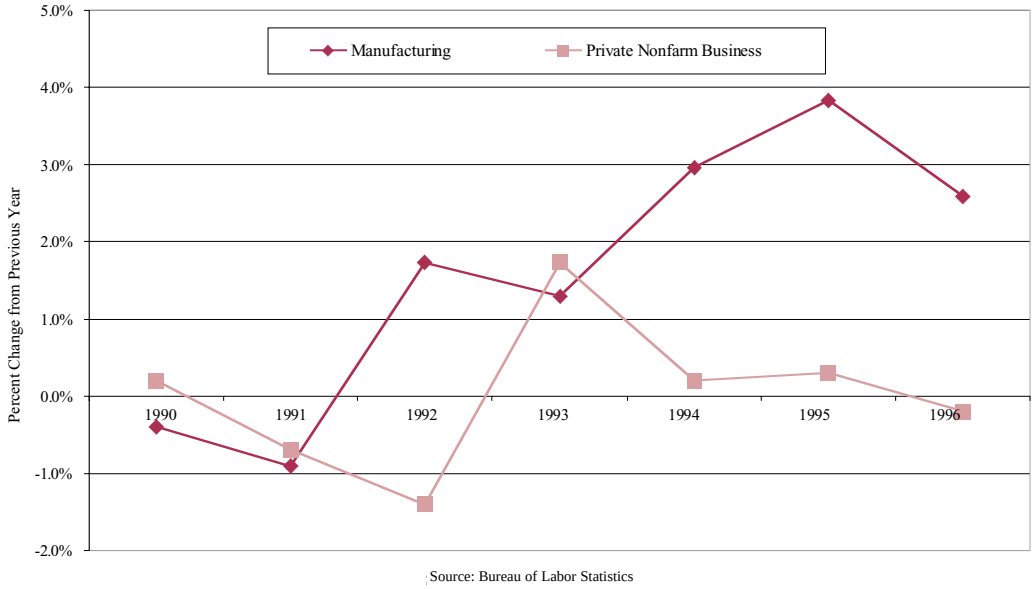
[5] Robert Gordon, "Has the 'New Economy' Rendered the Productivity Slowdown Obsolete?," Unpublished paper available from author, version dated June 14, 1999 (http://faculty-web.at.northwestern.edu/economics/gordon/334.pdf); Council of Economic Advisers, *Economic Report of the President*, (Government Printing Office: Washington, D.C., 2000): 80; Macroeconomic Advisers, "Productivity and Potential GDP in the 'New' U.S. Economy," September 1999; and NACFAM Manufacturing Productivity Database.

Figure 3: Manufacturing Pacing National Productivity



Source: Bureau of Labor Statistics

Figure 4: Manufacturing Leads Change in Multifactor Productivity



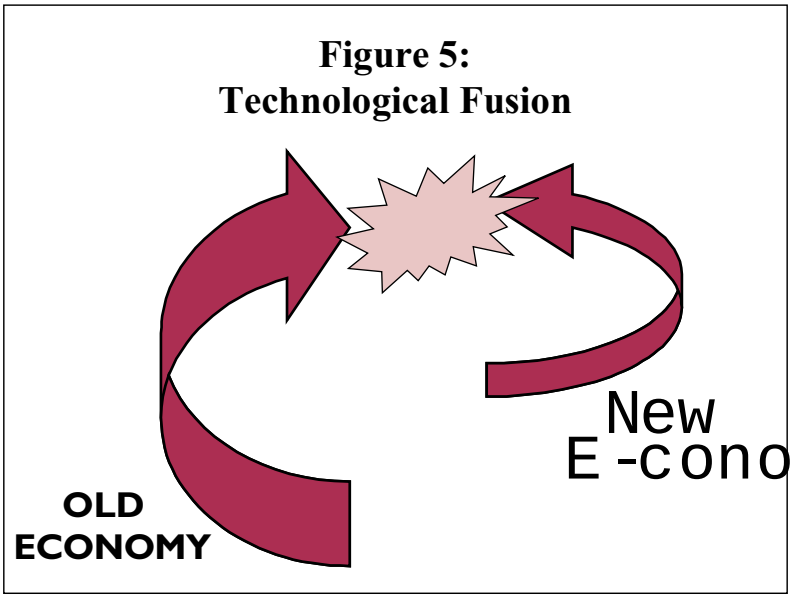
Source: Bureau of Labor Statistics

Manufacturing's Place in the 21st Century Economy

Wealth generation is the 21st century's public policy imperative. The "smart" way to increase the standard of living for all Americans is through wealth creation. Potential pressures on the economy demand greater attention by all to ensure that the factors driving prosperity remain strong and viable. Potential pressure on the economy is reduced if robust growth generates additional revenues to deal with societal needs such as Social Security, education, and health care.[6] Manufacturing is the most effective way for the United States to generate wealth in the 21st century economy. As an *engine for growth*, "manufacturing exercises the nation's productive capacities more extensively [than non-manufacturing industries], eliciting a broader array of inputs and providing special opportunities for productivity growth." [7]

> ***"Manufacturing will remain one of the principal means by which wealth is created."***
>
> ***National Research Council's Committee on Visionary Manufacturing Challenges***

Figure 5:
Technological Fusion



With greater attention focused on "new" economy industries, e-commerce, and the service sector, a belief has emerged that "old" economy activities, such as manufacturing, no longer matter. In fact, the "old" and "new" economies are not separating, as some suggest,[8] they are converging, and technology is driving this fusion (Figure 5). The stereotypical "bricks and mortar" manufacturer is increasingly turning to information technologies to connect with customers and suppliers.[9] Advanced technologies are embedded at all levels in manufactured products. Only the limits of creativity, technology, and engineering preclude the

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[6] National Academy on an Aging Society, Demography is Not Destiny (Washington, D.C.: Gerontological Society of America, January 1999).

[7] Economics and Statistics Administration, Engines of Growth (Washington, D.C.: U.S. Department of Commerce, July 1995): 8.

[8] An example of this false perception is Eamonn Fingleton's book, In Praise of Hard Industries (Boston, MA: Houghton Mifflin Co., 1999). Fingleton is right to "praise" hard industries, but goes too far in the opposite direction in his criticisms of information industries. There is no zero-sum relationship. The sectors are mutually dependent and exert positive influence on each other.

[9] The decision announced by Ford, General Motors and DaimlerChrysler in March 2000 to create "a business-to-business integrated supplier exchange through a single global portal" is the most recent example of how information technologies are transforming traditional manufacturers. For additional detail on the use of e-commerce techniques by manufacturers, see IndustryWeek, Census of Manufacturers: Third Annual Research Report (Cleveland, Ohio: IndustryWeek, 1999): 7-2; and National Association of Manufacturers, Press Release no. 00-60, February 22, 2000.

Extreme Ultraviolet Lithography Reveals Manufacturing Challenges of "New" Economy

In September 1997, a private industry consortium, led by Intel Corporation, Advanced Micro Devices and Motorola, was created with the Virtual National Laboratory (VNL) – consisting of three U.S. Department of Energy labs (Lawrence Livermore, Sandia, and Lawrence Berkeley) – to launch an advanced lithography research project targeted at increasing computer chip capabilities for the 21st century. The advanced lithography technology – called Extreme Ultra Violet (EUV) – will allow the industry to etch circuit lines smaller than 0.1 micron widths. This new technology will allow microprocessors to become 100 times more powerful and memory chips to store 1,000 times more information than is currently possible.

The group hopes to move developmental EUV technology into production factories. The EUV LLC (Extreme Ultraviolet Limited Liability Company), will invest $250 million in private funding between 1997-2002 to develop extreme ultraviolet lithography for commercial manufacturing of computer chips.

introduction of a host of new products exploiting advanced materials, bio-mechanical systems, or human-machine interfaces, just to name a few possibilities.

What is often lost in discussions about the "new" economy is how much of it depends on the health and vitality of the "old" economy. Estimates of retail e-commerce are substantial,[10] but are dwarfed in comparison to business-to-business transactions.[11] These business-to-business transactions fundamentally are about the efficient distribution of physical assets; assets which are eventually transformed into physical products.

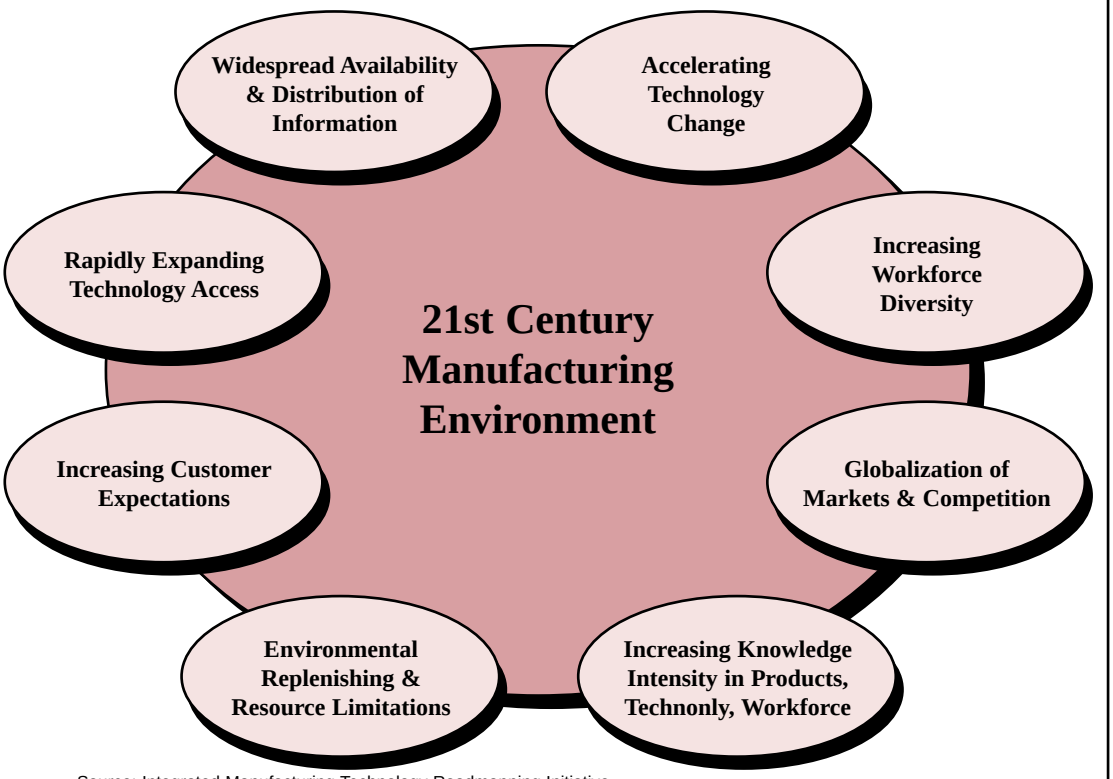
At the most basic level, the components of the 'new' economy are themselves manufactured products. Computers and computing equipment are advanced manufactured products requiring specialized facilities, skilled workers, access to a sophisticated technical infrastructure, and responsive supply chains and logistic systems. Computer and electronics manufacturers face significant hurdles, such as the lack of skilled labor, technical challenges to continue the reduction in physical size while simultaneously increasing performance with decreasing costs, and the manipulation of new materials. A particularly acute challenge, detailed in the box above, concerns the ability to sustain Moore's Law, which refers the ability to double the amount of data storage on a microchip every year or at least every 18 months. New lithography technologies are needed in order to manufacture computer chips at the same pace with the same quality as Moore's Law requires. The lithography case illustrates the broader point – the foundation of the 'new' economy is manufactured products.

Even if the technological barriers are overcome, the cost-effective mass production of quality products remains a critical problem. The same basic characteristics apply to pharmaceuticals and biotechnology. Problems faced by these industries will become the problems of the entire economy as electronics and bio-systems become embedded in everyday products.

[10] The Commerce Department's first estimates of retail e-commerce sales reported a 4th quarter FY 1999 figure of $5.3 billion, which was 0.64 percent of total retail sales for the same period. Press Release CB00-40, March 2, 2000.

[11] The Gartner Group estimates business-to-business (B2B) e-commerce will grow at aggressive rates through 2004, causing fundamental changes to the way businesses do business with each other. Worldwide B2B market is forecast to grow from $145 billion in 1999 to $7.29 trillion in 2004. By 2004, they estimate B2B e-commerce will represent 7 percent of the forecasted $105 trillion total global sales transactions. Press Release, January 26, 2000.

Figure 6: Forces Shaping the Environment for Manufacturing



Source: Integrated Manufacturing Technology Roadmapping Initiative

Other factors are changing the very nature of what it means to be a manufacturer in the traditional sectors. New technologies, particularly information technology, and the dynamic competitive environment are transforming the manufacturing enterprise and altering relationships between manufacturers and suppliers. Contract manufacturing is on the rise as many of the nation's prominent firms shift focus to design and marketing concerns.[12] Research and technology acquisition are being outsourced at higher rates in search of new sources of talent and innovative ideas while reducing internal expenditures and capacities for long-term research in the drive to become leaner and more efficient.[13,14] Small- and medium-sized businesses that comprise the supply chains for larger manufacturers are being asked to assume new roles and take on new tasks for which they may not be prepared. As technology changes and new processes are introduced, the skills of the incumbent workforce are put to the test and the ability to find entry-level workers with the appropriate skills is taxed.

The significance of these challenges to today's manufacturing base must be viewed in the context of what the 21st century economy needs from its manufacturers (Figure 6).[15] Keeping pace with rapid change in

[12] NACFAM, Proceedings of the AMLF Chicago Meeting, October 20, 1999; and "Contract Manufacturing is Growing Like Mad and Attracting New Participants," *Manufacturing News* (December 23, 1999: 1).

[13] NACFAM, Proceedings of the AMLF Detroit Meeting, December 7, 1999.

[14] PricewaterhouseCoopers estimates that 27 percent of businesses do not do long-term, basic research and 41 percent are outsourcing R&D projects amounting to 16.9 percent of their total R&D expenditures. "Technology Barometer," April 3, 2000.

[15] A number of studies in the last three years have looked at this question. For details see the National Research Council, Visionary Manufacturing Challenges for 2020; Integrated Manufacturing Technology Roadmapping

technology is only one of many factors forcing changes in the manufacturing industrial base. Customers are demanding more sophisticated products, embedded with the most advanced technologies, but remain incredibly sensitive to price.

Tomorrow's manufacturer must be flexible with the capability of using communications technology and knowledge sharing systems to respond to changing market demands. Customization will be the norm, rather than the exception. A manufacturing system must be adaptable to the changing needs of the consumer, but be intelligent enough to provide the right context so the consumer makes smart choices. Physical size will become less and less important as innovative processes will allow micro- or nano-scale manufacturing. Finally, a successful 21st century manufacturing operation will reduce production waste, effectively use new materials, and strive towards minimal environmental impact. Together, these pressures are changing the very meaning of what it is to be a manufacturer.

Initiative, Manufacturing Success in the 21st Century (Oak Ridge, TN: IMTI, Inc., 1999); and Agility Forum, Next-Generation Manufacturing (Bethlehem, PA: NGM Project Office, 1997).

The Path to "Smart Prosperity"

A "Smart Prosperity" strategy is dynamic, reflecting the changes in the economic environment, technological capabilities, and other salient points. Public policy communities across the United States must focus more diligently on preserving and strengthening the infrastructure on which future prosperity depends. As the work of NACFAM and the AMLF reveal, accomplishing this task will require the public and private sector to work cooperatively. The specific elements of the strategy will change as the environment in which they are made changes. However, two basic points are critical –

- The Infrastructure is Key – A strong and vital infrastructure, is needed to sustain economic growth over the long-term. A vital infrastructure provides the research and technical resources needed to generate new products and processes, workers with the education and skills they need to be productive and prosperous, and opportunities for businesses of any size to compete for a share of the market.

- Responsibility is Shared – No single organization can maintain the productivity infrastructure. Individual firms, workers, associations, universities, community colleges, and federal, state, and local governments all have contributions to make. The challenge for each is to recognize and fulfill their role. In many areas, cooperation and partnerships are needed to prepare the infrastructure for the future.

A "Smart Prosperity" strategy embraces these fundamental points. A key to understanding this agenda is recognizing the relationship between infrastructure and the transformation of manufacturing from a factory-centric enterprise to an extended, distributed system. A new production enterprise has emerged that requires a responsive and supportive infrastructure (Figure 7). Interpreting manufacturing as the simple fabrication of a part and/or assembly of parts into a product is unrealistic. Fabrication/Assembly is only one component of the "new" manufacturing system. Design, supply, fabrication, assembly, and distribution now comprise an integrated manufacturing enterprise. In turn, these components rest on a common infrastructure of technology, education and training, standards development, and SME extension systems.

The health of this infrastructure is important to the vitality of the manufacturing system as a whole. Each component must remain healthy because it is critical to the health of the system, with each affecting numerous organizations and operations. The interaction of the infrastructure with the production enterprise process produces the dynamism that sustains the economy. For example,

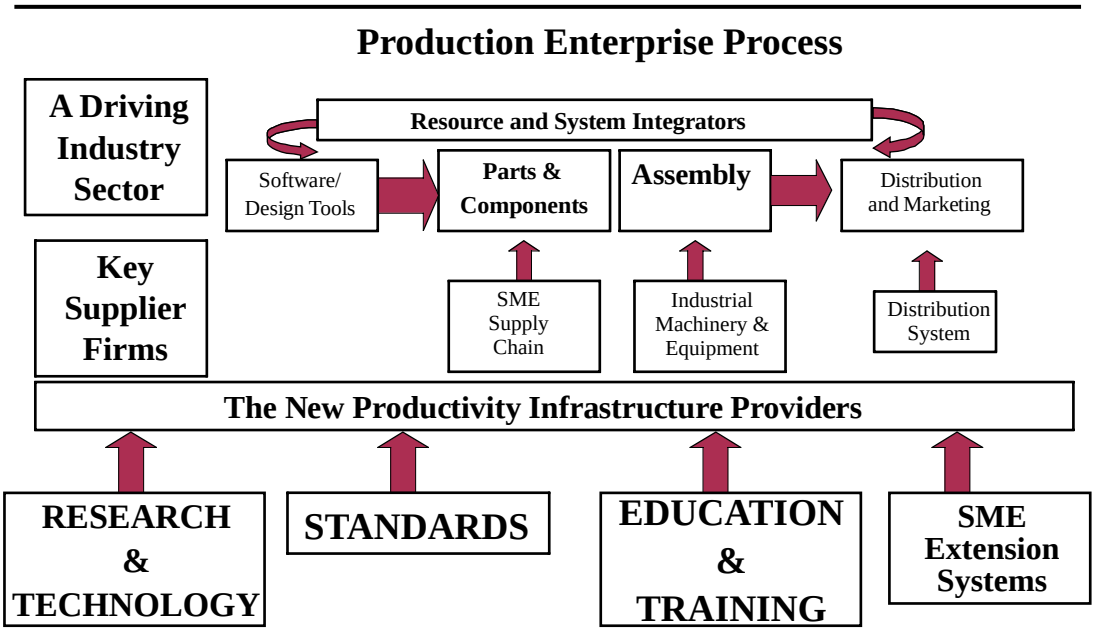
- New technologies influence design, components, assembly, and potentially even distribtion operations.

- Education and training systems directly influence the quality of the workforce on which all segments of the system depend.

- Small- and medium-sized manufacturing enterprises (SMEs) play significant roles at every part of the process, but face significant problems accessing advanced technologies and techniques.

- The ability to exchange information seamlessly and without data loss is a critical factor affecting the manner in which the different elements of the extended enterprise connect and communicate.

Figure 7: The New Production Enterprise



Source: NACFAM

Collective effort is required to prepare the infrastructure for the future. In each of these areas, different groups have the unique combination of interests and competencies that make them the leader of that area. Nevertheless, the infrastructure requires the input of multiple sectors working collectively if it is to retain the dynamic qualities, which allow it to change and adapt.

A number of steps can be taken today to strengthen this infrastructure. The AMLF divided these issues into three areas – (1) National Research Investment; (2) Workforce Skills Development; and (3) Enhancing the Performance of Small- and Medium-Sized Enterprise (SME) Supply Chains. Two policy proposals were developed for each (Figure 8). Collectively, the recommendations represent a recognition that the future productivity of the nation depends on the strength and capabilities of the infrastructure.

Figure 8: Public Policy Agenda of the Advanced Manufacturing Leadership Forum (AMLF)

NATIONAL RESEARCH INVESTMENT

Agenda Item 1: ***Grow and Reform the Federal Research and Development (R&D) Portfolio***

The federal government should adopt a two-pronged approach to increase support for engineering and the physical sciences. First, over the next three years, the government should commit to increasing its spending on research in these fields by $10.3 billion, beginning in FY 2002. Second, at least one-third of the proposed increase would be set aside for a research initiative focused on basic manufacturing science and technology.

Agenda Item 2: ***Encourage Collaborative Research Activities Through State Tax Credits and Other Experiments***

State governments are encouraged to approve research tax credits for expenses attributable to the activities of research consortia or adopt other means they deem appropriate to increase the use of research partnerships between industry, universities, federal laboratories, and non-profit research institutions.

WORKFORCE SKILLS DEVELOPMENT

Agenda Item 1: ***A Nationwide System of Industry-led Skill Standards, Assessment and Certification for Manufacturing***

Federal government, state government and industry should join forces to establish this system. The Manufacturing Skill Standards Council (MSSC) is researching the building blocks, but more substantial resources are needed to transform this work into a true nationwide system capable of reaching the entire manufacturing community.

Agenda Item 2: ***Technical Training Tax Credits***

The federal government should adopt two corporate tax credits to encourage greater technical training. The first confronts the scarce supply of entry-level trained workers by providing a corporate tax credit of up to $15,000 per employee per year for those in early formal training or apprenticeship programs. The second addresses the need for lifelong skill maintenance by establishing a corporate tax credit of 50 percent of the cost of formal training for front-line, hourly wage workers, up to a maximum of $2,500 per employee per year.

ENHANCING THE PERFORMANCE OF SME SUPPLY CHAIN

Agenda Item 1: ***Leverage the Manufacturing Extension Partnership (MEP) to Create a Robust Manufacturing Industrial Extension Infrastructure***

The Manufacturing Extension Partnership (MEP) needs to develop new services to ensure its continued relevancy to small- and medium-sized manufacturing enterprises. To accomplish this task, MEP must begin developing these services. Federal and state government must grant MEP greater flexibility to work with the private sector and put in place a new incentive structure to reward success.

Agenda Item 2: ***Develop a Voluntary Common Electronic Framework for Supply Chain Integration***

The private stakeholders should take the leadership to build a voluntary common electronic framework for supply chain integration. The purpose would be to enable interoperability between IT systems without sacrificing the unique characteristics and advantages of proprietary systems.

Policy Area 1:

NATIONAL RESEARCH INVESTMENT

The longest economic expansion in U.S. history -- sustained economic growth since 1991 -- is driven by consistent increases in the rate of productivity growth. With greater productivity, the economy can grow more rapidly on a sustainable basis. In analyzing the cause of this growth, a strong consensus is emerging that technology is a critical driver of productivity growth.[16] In turn, the future development of technology depends on investments made today in basic and applied research. To sustain and accelerate these trends, resources must be committed now to ensure that the technical needs of the future can be met. In particular, the research required for the development of the next generation of advanced manufacturing technologies demands a sustained national commitment, especially given the close relationship between these technologies and productivity growth.

> ***"The growth of economies throughout the world since the industrial revolution began has been driven by continual technological innovation through the pursuit of scientific understanding and application of engineering solutions."***
>
> ***National Science Policy Report of the House Committee on Science***

As the economy has expanded throughout the 1990s, investment in one of the critical drivers of that growth, long-term research, has seen its position erode as a share of total economic activity. Since 1991, federal basic and applied research expenditures have declined, as a percentage of GDP, from 0.5 percent to 0.398 percent (Figure 9). The drop in federal support is most troubling because of the government's long-standing role as the principal supplier of funds for research activities of a long-term and high-risk nature. In fact, public investment in manufacturing-related R&D is less than 5 percent of all federal R&D.[17] Even though industrial expenditures on R&D continue to rise, this investment focuses more on short-term product development programs and less on longer-term applied and basic research.[18]

Consequently, there is a real danger of underinvesting in those areas most essential to future economic prosperity. Investing today in the research areas required for future manufacturing products and processes is the only way to make sure these capabilities will be available when the time comes to draw on them. This conclusion is shared by the National Research Council's Committee on Visionary Manufacturing Challenges, who warned:

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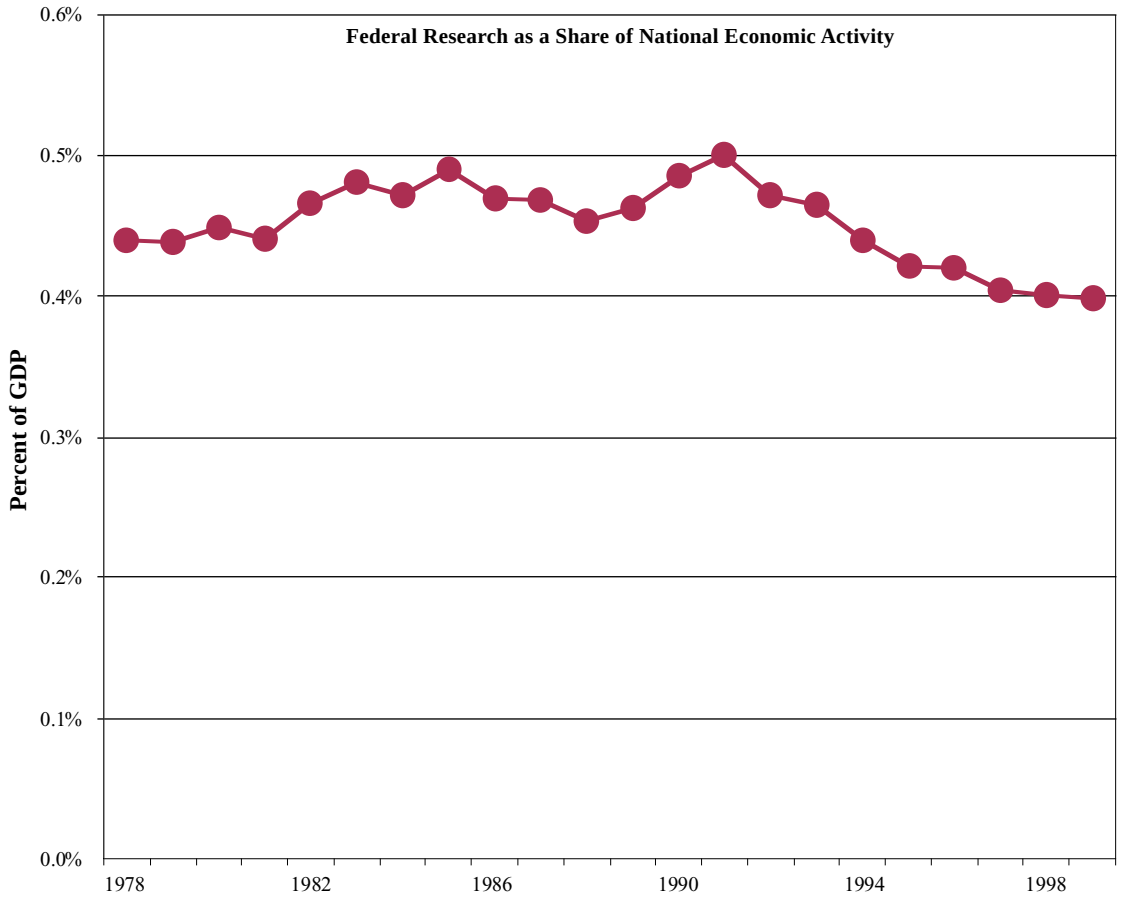
[16] For example, see J.D. Adams, "Fundamental Stocks of Knowledge and Productivity Growth," *Journal of Political Economy* 98(4), 1990: 673-702; Dale Jorgenson, "Investing in Productivity Growth," Technology and Economics (Washington, D.C.: National Academy Press, 1991); and Zvi Griliches, R&D, Patents, and Productivity (Chicago: University of Chicago Press, 1984).

[17] According to the Integrated Manufacturing Technology Initiative, Enabling Critical Solutions for Manufacturing Success (Oak Ridge, TN: IMTI, 2000), federal manufacturing-related R&D is approximately $3 billion per year. The National Science Foundation estimates federal R&D spending for 1999 was $65.8 billion in current dollars adjusted for calendar years (National Patterns of R&D Resources 1999 Data Update). The American Association for the Advancement of Science (AAAS) estimates federal R&D expenditures for FY 1999 were $80.17 billion in budget authority.

[18] R&D Magazine, "Industry Spends Big on Development While Feds Focus on Research," *2000 R&D Funding Forecast* (http://www.rdmag.com/features/0100forecast_forecast.htm); and PricewaterhouseCoopers, "Technology Barometer," April 3, 2000.

Figure 9: Federal Commitment to Long-Term Research Slipping



Note: Research is the summation of federal expenditures on basic and applied research. Constant 1992 dollars and NSF GDP data used.
Source: National Science Foundation, National Patterns of R&D Resources, 1999 Data Update.

"The recent pace of technological advances could lead to complacency and the belief that technology will be available 'on demand.' Today's advances, however, were the result of exploratory enabling research performed years ago. If manufacturing is to have the technical capabilities it needs in 2020, the research that will provide the scientific basis for these capabilities must be initiated now." [19]

[19] National Research Council, Visionary Manufacturing Challenges for 2020 (Washington, D.C.: National Academy Press, 1998): ix.

Agenda Item 1: *Grow and Reform the Federal Research and Development (R&D) Portfolio*

The federal government should adopt a two-pronged approach to increase support for engineering and the physical sciences. First, over the next three years, the government should commit to increasing its spending on research in these fields by $10.3 billion, beginning in FY 2002. Second, at least one-third of the proposed increase would be set aside for a research initiative focused on basic manufacturing science and technology.

Technology is the fuel of the "new" economy. The application of advanced technologies, ranging from information and computing technologies to the use of new materials and process technologies, are fueling the current economic boom.[20] These technologies are the product of knowledge, competencies, and capabilities of the national research infrastructure. This research base must evolve and expand as the economy changes.

In particular, public commitment to expanding support for long-term research and technology is necessary.[21] The character of federal investment in R&D has taken many forms, ranging from support of mission-related to discovery-driven research. In many cases where public support was closely aligned with industrial needs, the government did not shy away from assuming a leadership role, but instead, structured its involvement to address collective and generic needs. There was a shared understanding that public support was necessary to overcome market imperfections that result in underinvestment in certain types of R&D or in certain technical areas. The long-term, high-risk, and diffuse applicability of the research activities in question make them unattractive to the industrial R&D community, which is focused increasingly on short-term, product development. In today's fiercely competitive marketplace, consumers will not pay more for products from a company that does long-term research. Similarly, today's stock market does not reward companies for doing basic research. Consequently, industry more and more depends on the broad foundation of research results and intellectual capacity arising from federal support for work at universities, federal laboratories, non-profit research institutes, and industrial laboratories.

An important, but often overlooked, benefit of federal research funding is the education of young scientists and engineers. Federal support directly influences the ability of universities and colleges to support undergraduate and graduate students. These students are the future leaders of businesses and universities, the catalysts for continued technological innovation, and, consequently, a critical contribution to future economic prosperity.

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[20] Alan Greenspan, "Technology and the Economy," Remarks before the Economic Club of New York, January 13, 2000 (http://www.bog.frb.fed.us/BoardDocs/Speeches/2000/200001132.htm); and Gregory Tassey, R&D Trends in the U.S. Economy: Strategies and Policy Implications, (NIST Planning Report 99-2, April 1999).

[21] In recent years, a number of groups have made similar calls. For example, Committee for Economic Development, America's Basic Research: Prosperity Through Discovery (New York: CED, 1998); National Research Council, Harnessing Science and Technology for America's Economic Future (Washington, D.C.: National Academy Press, 1999); Bluestone and Harrison, Growing Prosperity; and the various groups working on behalf of the so-called R&D Doubling Bills, which would authorize large increases in federal civilian R&D spending. The first component of this recommendation is clearly consistent with the intent of the R&D Doubling effort.

"With the end of the Cold War, the strongest rationale for increased federal R&D spending is economic growth. Only growth elevates the nation's capacity to deal with all future challenges, both civilian and military, while simultaneously raising the standard of living of all Americans."

Leo Reddy,
President, NACFAM

Continued public sector support for long-term research and technology is a particularly relevant problem in the manufacturing sector.[22] Recent studies of the future technical needs of manufacturing reveal numerous gaps in the knowledge base.[23] Moreover, many large manufacturers, who used to assume the lead for R&D related to manufacturing processes, are outsourcing manufacturing operations to smaller firms, who have relatively modest R&D capabilities.[24]

Without question, industry will have to assume great responsibility for tackling many of these technical challenges, but it is equally true that the mission needs of federal agencies are also affected by these research questions.[25] Additionally, as policy makers search for new rationales to sustain public investment in research and development in the post Cold War era, there is a growing consensus that society's interest in maintaining economic prosperity can serve as a rallying point for greater public investment in scientific and technical activities.

When public investment in long-term research is benchmarked against the performance of the economy as a whole, there is a clear indication of looming investment shortfall. Figure 9 shows quite clearly that as the economy raced ahead in the 1990s, driven by the application of advanced technologies, public investment in the research infrastructure that produced those innovations consistently fell as a percent of national economic activity. Since the early 1980s, the same trend is evident in federal support for the fields most directly related to productivity improvement in manufacturing (Figure 10).[26]

To address this situation, two steps are suggested. The first step increases federal support for engineering and physical sciences by $10.3 billion over three years beginning in the first fiscal year budget (FY 2002) of the next Administration. The recommended increase would only return both field's share of GDP to the level they held in the early 1980s.[27] This recommendation does not

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[22] Manufacturing-related research and technology clearly falls into the "use-inspired" category where activities are "inspired by considerations of use," (Donald Stokes, Pasteur's Quadrant: Basic Science and Technological Innovation (Washington, D.C.: Brookings Institution, 1997: 73-74)).

[23] National Research Council (1998) and Integrated Manufacturing Technology Roadmap (1999).

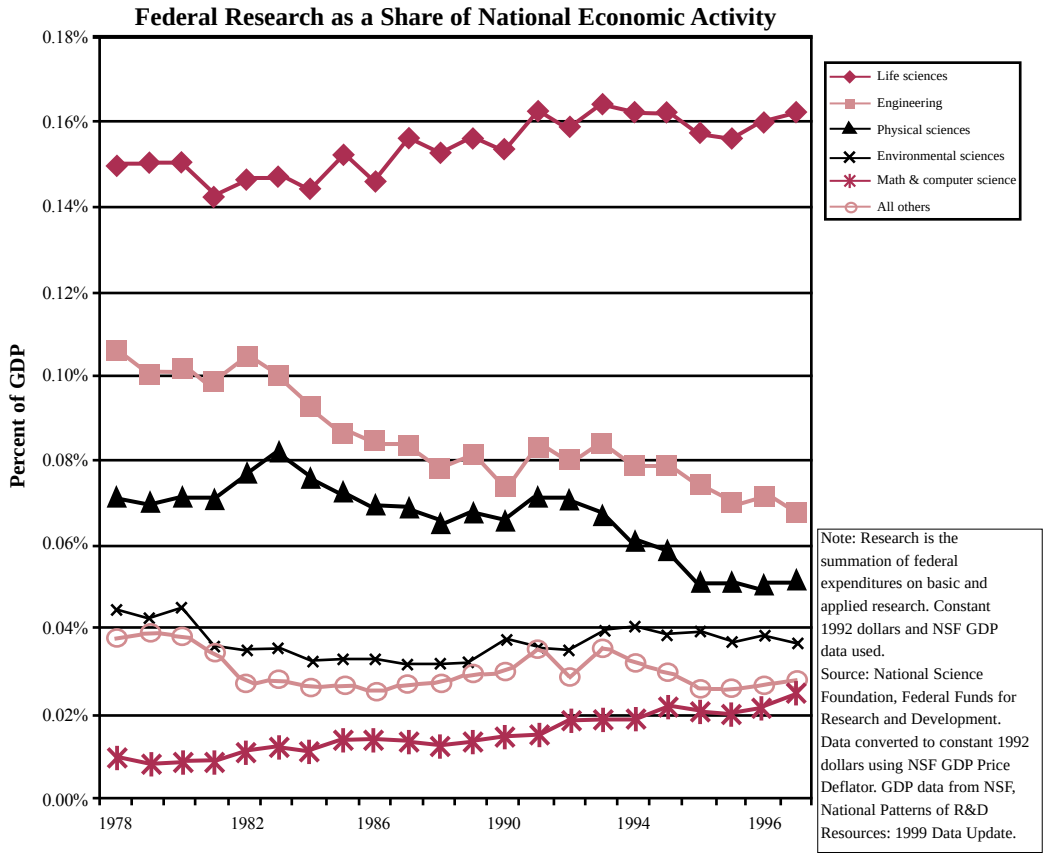
[24] NACFAM, Proceedings of the AMLF Palo Alto Meeting, February 29, 2000.

[25] For example, National Research Council, Manufacturing Process Controls for the Industries of the Future (Washington, D.C.: National Academy Press, 1998); and National Research Council, Defense Manufacturing in 2010 and Beyond: Meeting the Changing Needs of National Defense (Washington, D.C.: National Academy Press, 1999).

[26] As a share of national GDP, engineering basic and applied research by the federal government fell from 0.1% in 1982 to 0.068% in 1999. The physical sciences dropped from 0.077% to 0.052%. In constant dollars, government expenditures were flat during the period, indicating that the level of federal effort has not kept up with the expansion of the economy.

[27] The total is calculated as follows: (1) Engineering – Increase federal expenditures to $11.54 billion over three years (engineering research in 1999 was $5.2 billion, according to National Science Foundation data). According to Congressional Budget Office projections of national GDP for 2004, that level of spending would return federal expenditures on engineering research (basic and applied) to 0.1% of GDP. (2) Physical sciences – Increase federal expenditures to $8.08 billion over three years (physical science spending in 1999 was $4 billion, according to NSF). Using the 2004 GDP projection, this level would return federal spending on the physical sciences to 0.07% of GDP, which is the rough average share of GDP between 1978-1982.

Figure 10: Federal Investment in Engineering and Physical Sciences' Falling



preclude the continued expansion of other scientific disciplines.[28] The clear intent is to reenergize the public commitment to those scientific and technical disciplines that are critical to the industrial research and technology infrastructure and that most directly enhance productivity growth.

The second step is the creation of a basic manufacturing science and technology initiative. Drawing on recent efforts to identify priorities to meet the future technological needs of manufacturing, this initiative would commit federal funds to address those areas where the private sector is least likely to act. This initiative would allocate a minimum of $3 billion over three years above current levels – a one-third increase.[29] The research priorities identified by the National Research Council and

[28] The so-called "R&D Doubling" bill would increase federal expenditures on civilian research over ten years. This recommendation is consistent with the "Doubling" effort. Both call for greater attention to balancing federal expenditures across scientific disciplines and both maintain that public support for research is important to the economic vitality of the nation. The AMLF recommendations are distinguished from other efforts by their singular focus on manufacturing and their inclusion of the Defense Department. The "Doubling" effort excludes the DOD. This recommendation recognizes the significant role DOD fills in the federal manufacturing science and technology infrastructure.

[29] The federal government currently supports a manufacturing R&D portfolio of about $3 billion per year, according to IMTI. This is spread across several agencies and departments. The Defense Department, and its related agencies, is the single largest sponsor, with responsibility for nearly 75% of the portfolio. The Advanced Technology Program (ATP) ranks second at 18%. The Department of Energy, NIST's Manufacturing Engineering Laboratory, and the National Science Foundation have manufacturing programs accounting for 7% of the total. The National Aeronautics and Space Administration (NASA) maintains a large portfolio of manufacturing projects but are not included on this list because budget data was not available. Integrated Manufacturing Technology Initiative, *Gap Analysis* (2000).

Integrated Manufacturing Technology Roadmapping efforts could serve as a starting point, but industry input would be sought to further refine the technical agenda (for examples of possible technical areas for investment see Figure 11).[30]

The federal government can choose from a variety of strategies to distribute the resources from both recommendations. Conclusive evidence does not exist that one method works more effectively than the others. In fact, given the growing complexity of technology and the multidisciplinary character of research needs, the desirability of partnerships and collaborative research activities is expanding beyond the simple desire to leverage more resources. The traditional use of grants and contracts will remain a cornerstone with good reason, but it may be time to consider radical new distribution systems. One approach would be to have states and local governments assume important roles as bridges between the long-term research interests of the federal government and the shorter-term interests of the private sector through the creation of manufacturing technology institutes financed through federal-state matching funds. This would be consistent with the House Science Committee's *National Science Policy* report, which stated that:

> "Partnerships that tie together the efforts of state governments, industries, and academia also show great promise in stimulating research and economic development. Indeed, states appear far better suited than the federal government to foster economic development through technology-based industry. As the principal beneficiaries, the states should be encouraged to play a greater role in promoting the development of high-tech industries, both through their support of colleges and research universities and through interactions between these institutions and the private sector."[31]

No single implementation strategy is sufficient. The 21st century research enterprise requires multiple combinations of strategies and actors.

Regardless of which combination of implementation options is ultimately chosen, the suggested increases are essential to reverse the observed decline in manufacturing-related research over the last decade. Efforts to increase federal R&D spending in recent years are welcome, but do not reach the scale or the focus suggested by this recommendation.[32] Focused attention on those research and technology areas most critical to the future of manufacturing enterprises is needed if the United States is to sustain the remarkable rates of productivity growth, and subsequent economic prosperity, currently being enjoyed.

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[30] Figure 11 is the product of a NACFAM workshop of leading technologists who were asked to identify technologies that were driving productivity improvements today and offer their views on what kinds of technologies would do the same in 2010. Other examples of research needs for advanced manufacturing technology can be found in National Research Council, Visionary Manufacturing Challenges for 2020, and the Integrated Manufacturing Technology Roadmap, 1999.

[31] House Committee on Science, Unlocking Our Future: Toward a New National Science Policy (Washington, D.C.: Committee Print 105-B, September 1998): 78.

[32] The Clinton Administration's request for FY 2001, for example, targets a $2.86 billion increase for the 21st Century Research Fund as significant for manufacturing (*Strengthening Manufacturing for the 21st Century*, White House Fact Sheet, February 5, 2000). The scope of the Research Fund, however, goes well beyond manufacturing and is intended to highlight federal investments in basic and applied research (*FY 2001 Budget Request for Research*). The National Institutes of Health represent 43% of the FY 2001 request for this fund and account for 35% of the proposed increased. The major program designated as benefiting manufacturing is the nanotechnology initiative, funded at $495 million for FY 2001. While this is a promising and important initiative, it deals with only a limited segment of manufacturing process technology. This recommendation advocates levels of investment and concentration on manufacturing research and technology development questions that go well beyond those planned in the FY 2001 budget request.

Figure 11

High-Value, Productivity-Enhancing Technologies Now and 2010

Now	2010
Sensors	**Sensors**
Statistical control, machine sensors	Synthesis of sensor data to provide knowledge and generate data that sense process and product change needs
Modeling and Simulation	**Modeling and Simulation**
CAD/CAM Digital	Virtual reality for process and systems models, Intelligent agents, Prognostics on products
Materials	**Materials**
Engineered materials, e.g. composites	Production at reasonable cost and predictable performance, Smart materials, Green materials/processes
Information Technologies	**Information Technologies**
Internet, Web-based standardization, Virtual enterprise	Seamless, real-time total interoperability, Point of sale/use info, Digital infrastructure, Knowledge capture and distribution across the enterprise
Biotechnology	**Biotechnology**
Bio/agriculture, pharmaceuticals	Artificial skin, Tailored/adaptable drugs, Organic materials
Training/Education	**Training/Education**
Classroom/mass produced, Virtual reality for highly paid people	Point and time of need, Tailored to level of detail, Virtual reality for the factory floor
Green Manufacturing	**Green Manufacturing**
Recycle, Emissions control	Reduce energy use, Total life cycle is green, Lifetime warranty
Robotics/Intelligent Machines	**Robotics/Intelligent Machines**
PCs on factory floor, High speed machines	Speech based/ human machine interface, Learning/ teaching machines, Sensor fusion, Distributed agile mfg/ assembly enterprise, Very large parts, Very high speed machines

Note: Participants defined technologies in use today that resulted from public or private investment that increased productivity and resulted in the favorable position enjoyed currently by the United States. They then defined those technologies that will help the U.S. in 2010 if investments are made in the intervening period.

Source: NACFAM, Assessment of Economic and Technological Factors of Productivity Growth: Report of a Workshop (Washington, D.C.: NACFAM, December 7-8, 1998)

Agenda Item 2: *Encourage Collaborative Research Activities Through State Tax Credits and Other Experiments*

State governments are encouraged to approve research tax credits for expenses attributable to the activities of research consortia or adopt other means they deem appropriate to increase the use of research partnerships between industry, universities, federal laboratories, and non-profit research institutions.

The new manufacturing production enterprise is a networked system (see Figure 7) where success will depend in large part on the ability of firms to leverage the capabilities and intellect of the other participants in the process. Complete vertical integration with an exclusive production process is no longer efficient or cost-effective. Manufacturers must collaborate to survive. This transformation is evident in the restructuring of supply chain relationships and in industrial attitudes toward research and technology. Increasingly firms are outsourcing research activities to leverage the resources invested by others and to access their competencies and capabilities.[33]

Collaborations and partnerships are increasingly important sources of support for long-term, high-risk research.[34] In a highly competitive economic environment, even the largest firms are cutting back long-term research funding and focusing efforts on projects with shorter timeframes and greater linkages to products,[35] because the capacity to appropriate the returns to research in path-breaking, multi-use, and generic technologies is low.

Additionally, since many of the fastest growing and most innovative fields are broad and multidisciplinary, capitalizing on these areas requires expertise that crosses many disciplines. In many areas, the accumulation of the necessary expertise, information, and technologies under one organization simply is not possible or within reasonable expense. The complexity of technologies that drive economic change renders obsolete the notion that a single organization can provide itself with all the capabilities and information required to succeed in a technical enterprise.[36]

Finally, collaborative research on a broad scale may be the only way to overcome the "Valley of Death" problem of moving research into productive technologies.[37] Research indicates that companies are less willing to partner on close-to-market activities, but find joint ventures or other cooperative relationships attractive for process stage research or other generically applicable or non-appropriable research activities.[38]

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[33] NACFAM, Proceedings of the AMLF Detroit Meeting, December 7, 1999; and PricewaterhouseCooper's "Technology Barometer," April 3, 2000.

[34] Gene Allen and Rick Jarman, Collaborative R&D: Manufacturing's New Tool (New York: John Wiley & Sons, Inc., 1999).

[35] R&D Magazine (2000).

[36] Robert Rycroft and Don Kash, "Innovation Policy for Complex Technologies," *Issues in Science and Technology* (Fall 1999: 73-79).

[37] House Committee on Science, Unlocking Our Future (1998):39-40.

[38] Yong Lee, "University-Industry Collaboration on Technological Innovation: Assessing Behavioral Outcomes," *Unpublished Manuscript at Iowa State University*, March 1999.

The states are uniquely positioned to offer incentives for research collaborations aimed at translating basic research or fundamental knowledge into applied productivity-enhancing technologies.[39] Both the private sector and the federal government recognize the importance of collaborative activities as a means to spur innovation and leverage scarce resources. However, constraints on both industry and the federal government prevent them from exploiting these mechanisms to their fullest. States are naturally more concerned with their local and regional economies and have a long history of using public policy to encourage economic development.

"States are natural channels of technology deployment and commercialization, because they are attuned to the needs and structure of local and regional industry and have strong and direct political incentives to produce tangible economic results in the form of new wealth and employment gains."

Christopher Coburn and Duncan Brown, Battelle Memorial Institute and the National Research Council

State governments are encouraged to adopt tax credits covering a predetermined percentage of the expenses attributable to participation in a collaborative research project or consortia. The proposed credit would apply to any combination of organizations, such as industry-university, industry-government, or industry research consortia. This proposal is modeled on the successful federal R&D tax credit, which at this point in time, does not cover expenses incurred for collaborative activities. Additionally, states are encouraged to continue exploring other means of encouraging collaboration, including the use of direct investments and creation of institutes to leverage private investment in technologies critical to regional economic development.

State participation in this national effort to preserve and expand the research infrastructure is absolutely essential. It is the only public institution with the incentives and capacity to substantially broaden public support for collaborative R&D. Several federal programs currently foster collaborative research, such as the Advanced Technology Program (ATP) and the Small Business Technology Transfer Program (STTR). These programs leverage federal funds to form R&D partnerships. However, these programs are limited by available funds and restrictions on their scope. Also, several bills are pending in the U.S. Congress to create a 20 percent tax credit on expenses incurred as the result of participating in a collaborative research project or consortia,[40] but the extension of the R&D tax credit for 5 years in November 1999 will make it extremely difficult to secure a federal tax credit for collaborative R&D. In sum, increased federal action to support collaboration at the scale required is improbable.

While the economic evidence on the R&D credit varies, most reviewers have found the credit to increase R&D activity.[41] A collaborative credit is expected to produce similar or larger effects. Industry representatives believe the credit would provide a major stimulus to such activities, encouraging top corporate and financial managers to recognize the fiduciary and technical benefits of partnerships.[42] As noted above, other methods of stimulating partnering certainly exist and states are encouraged to experiment.

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[39] House Committee on Science, Unlocking Our Future (1998): 42; and National Research Council, Harnessing Science and Technology (1999).

[40] H.R. 1328 has gained substantial bipartisan support for providing a 20 percent research credit for expenses attributable to the activities of research consortia. S. 951 and H.R. 1682 extend the credit to cover research consortia expenses, but, in addition, expands it to cover any university-industry or industry-federal laboratory research, as long as the results are made public.

[41] Bronwyn Hall and John van Reenen, "How Effective are Fiscal Incentives for R&D? A Review of the Evidence," (NBER Working Paper 7098, April 1999).

[42] NACFAM, Proceedings of the AMLF Palo Alto Meeting, February 29, 2000.

Policy Area 2:

WORKFORCE SKILLS DEVELOPMENT

A major obstacle to productivity growth in the U.S. economy, including the manufacturing sector, is the critical shortage of workers with the skills and knowledge needed to keep pace with rapid technological change. Of the factors driving productivity growth – technology, capital, management and workforce skills – none is more important than the latter. According to a Bureau of the Census study,[43] investments in workforce education and training have the highest correlation to corporate productivity growth. Moreover, workforce skills have made an increasingly important contribution to productivity growth since 1979, and employment has shifted towards occupations requiring higher levels of education and knowledge.[44]

Despite the central importance of workforce skills and knowledge to productivity growth, it is precisely in this area that the U.S. is confronting profound, long-term challenges:

- Deficiencies in basic skills requirements - Although the overall education level of American workers is increasing steadily, significant deficiencies persist in basic skills and knowledge. According to a survey by the American Management Association, 43 percent of job applicants for manufacturing jobs in the U.S. in 1998 lacked sufficient reading and math skills.[45]

- Demand far exceeding supply - The demand for skilled knowledge workers far exceeds the supply. High tech industries are seeking to fill over one million new jobs by the year 2005. GM, Ford and Daimler-Chrysler need to fill over 200,000 skilled jobs within the same time frame. Yet 88 percent of manufacturers report difficulties in finding qualified candidates in at least one job function.[46]

"Skills have become a more important source of productivity growth in the 1990s and now contribute more than a quarter of all growth in labor productivity."

U.S. Department of Labor, Report on the American Workforce

- Restraint on Business Growth - A 1999 survey of 300 senior management executives by Select Appointments North America reported that the shortage of skilled workers was limiting sales by as much as 33 percent and represented the single greatest challenge facing U.S. business. A 1998 survey reported that 4 out of 10 executives of manufacturing firms cited the shortage of skilled workers as the principal obstacle to purchasing new machinery and equipment, hardware and software.

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[43] Education Quality in the Workforce, Prepared by Wharton School for the U.S. Bureau of Census, 1998

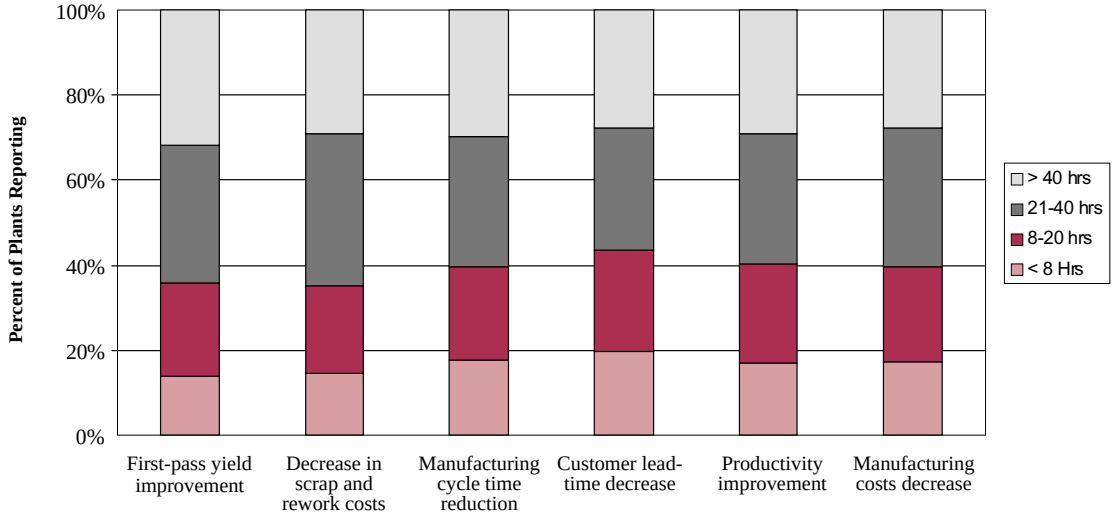
[44] U.S. Department of Labor, Report on the American Workforce (Washington, D.C.: Government Printing Office, 1999): 44.

[45] The implication is that often workers require basic reading and math skills before they are capable of learning the skills needed for the job. Several participants at the Chicago meeting of the AMLF spoke of their efforts to handle this basic education problem. NACFAM, Proceedings of the AMLF Chicago Meeting, October 20, 1999.

[46] Grant Thornton and the Center for Workforce Success, The Skills Gap, (1998).

Figure 12:
Impact of Formal Training on Selected Metrics

(Annual Hours of Formal Training per Plant Employee)



Source: IndustryWeek, Third Annual Census of Manufacturers (1999)

- Underinvestment in Lifelong Training - Formal training of the technical skills of the incumbent workforce is one of the most efficient ways to increase productivity. Employers that provide formal training for their employees see a 15 to 20 percent average increase in productivity.[47] Although company investment in technical training is growing, it varies widely across industries. For example, over the 1989-97 period, skill levels rose by only 0.2 percent in the goods-producing sector and by 1.4 percent in the service-producing sector.[48]

Overcoming these issues will not be easy, but the potential economic benefits are enormous. Instituting ways to improve the skill sets of incumbent and entry-level workers for the near- and long-term future will positively influence productivity growth and company performance. Recent surveys of manufacturers demonstrate the positive economic returns to training and investment in human capital. Plants with greater commitment to formal training see improvement along a spectrum of performance metrics (Figure 12).

For the worker, added skills means rising wages and enhanced career opportunities. Moving along the "knowledge levels," as defined by the Department of Labor, results in consistently rapid increase in average hourly wage rates. For example, in 1998, precision production workers jumping from the first "knowledge level" to the second saw their wages jump 45 percent.[49] The benefits of an expanded skill set are more than just monetary. Rapid change in work environments raises the possibility that workers may

[47] U.S. Departments of Commerce, Education and Labor, 21st Century Skills for 21st Century Jobs, (Washington, D.C.: Government Printing Office, January 1999).

[48] U.S. Department of Labor (1999): 44-45.

[49] U.S. Department of Labor (1999): 69.

change jobs more frequently. This uncertainty creates great psychological stress on the worker and their families. Providing these workers with the means to improve their skills helps them to adapt with changes in the marketplace.

For the nation, the pay-offs from such investments in the future of working families are incalculable. Not will tax receipts rise, but pressure on the social safety net programs will dissipate as incomes rise. Additionally, increased opportunities for employment address root motivations driving social tensions, crime, and poverty.

Agenda Item 1: *A Nationwide System of Industry-led Skill Standards, Assessment and Certification for Manufacturing*

Federal government, state government and industry should join forces to establish this system. The Manufacturing Skill Standards Council (MSSC) is researching the building blocks, but more substantial resources are needed to transform this work into a true nationwide system capable of reaching the entire manufacturing community.

Manufacturers have improved their economic performance by investing in new capital equipment endowed with advanced technologies, including computer hardware and software, implementing the use of new processes, which are often based on teamwork, and instituting new organizational structures. These new production systems require multi-skilled production technicians who are capable of dealing with an expanding set of advanced technologies.[50] Jobs for workers without the skills needed to operate successfully in this environment are rapidly vanishing. By 2005, the number of unskilled manufacturing jobs is projected to shrink to 15 percent, down from 30 percent in 1998.[51] These changes, combined with the noted shortage of skilled workers and changes in the structure of the manufacturing environment, present severe challenges to the American workforce.

Workers and businesses must keep pace with changes in the economy and in technology. Unfortunately, the tools available to workers for dealing with these changes are inadequate. Reliable information about skills requirements and related education needs and career ladders are difficult to find and there is no clear system for skills documentation. There is a need for improved training and education to help entry-level and incumbent workers gain the skills they need to compete successfully.

The first step in this process is for manufacturers to clarify with greater precision the skills, and related standards, required by their workforce. Skill standards are a powerful means for companies to communicate their precise workforce needs to educators and trainers. When integrated into curriculum and learning systems, standards help close the gap between the needs of the manufacturing community and the skills and knowledge imparted by the education and training communities. This closer alignment between business requirements and education will generate larger pool of workers with relevant skills and enhance national productivity growth.

Within companies, skill standards become the foundation for a system of recruitment, training and compensation that, when integrated into a company's overall program for continuous improvement, lead to substantial improvements in productivity and growth. Moreover, documentation and certification provide individual workers with greater flexibility and with portable credentials that help them keep pace with technological change and deal with the accelerated turnover of jobs within industry.

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[50] One estimate suggests that 90 percent of all U.S. manufacturers now employ computer-aided design and two-thirds used total quality management programs, just-in-time inventory systems, computer-numerical controls, statistical process control, and computer-aided manufacturing. Paul Swamidass, Technology on the Factory Floor (Washington, D.C.: Manufacturing Institute, 1995).

[51] National Alliance of Business, *Workforce Economics*, (1996).

> ***"Manufacturers in this country will be competitive if and only if we have a definition of what it takes to be successful . . . skill standards are that benchmarking element."***
>
> ***John Rauschenberger, Ford Motor Company***

Under the auspices of the National Skill Standards Board (NSSB), the Manufacturing Skill Standards Council (MSSC) has taken a lead role in bringing the extended manufacturing community together to develop a nationwide system of standards, assessment, and certification. The MSSC is presently conducting research on the elements of such a system and is scheduled to release its first set of scientifically validated national skill standards in the summer of 2000. The MSSC itself is a powerful coalition of some 170 leading corporations, unions, national education associations, and professional societies. The nationwide system emerging under the leadership of the MSSC draws strength from the participation of these organizations and has unique roles and responsibilities for each. Specifically, the system would consist of the following elements (see also Figure 13):

- The MSSC develops and continuously updates core[52] and concentration[53] standards applicable to all sectors of manufacturing and occupations--from front line to first line of supervision--related to production and production support;
- Trade associations and professional organizations develop specialty standards for production and/or production support workers under NSSB guidelines, which are reviewed and endorsed by the MSSC;
- Industry and government promote these standards broadly, including through 0*NET, the U.S. Department of Labor's new electronic network for disseminating occupational information to individuals, companies, schools, and one-stop career centers;
- Curriculum development organizations and publishers use these standards as a basis for new curriculum and related learning materials more closely aligned to the actual needs of the workplace;
- Education and training organizations train teachers on the use of standards in curriculum and learning and build closer relations between educators and manufacturers;
- Providers of workforce education integrate these skills standards into their training initiatives;
- The MSSC authorizes various education and training institutions to assess and certify individuals against MSSC standards, with qualified individuals receiving certificates for core plus a concentration ("Core + One");
- Companies use MSSC standards, documentation and certification for individuals as a foundation for more efficient recruitment, just-in-time training, and pay-for-skills compensation systems.

[52] "Core" refers to the core skills within manufacturing and concentrations refer to a more specific functional area within manufacturing.

[53] Concentrations currently being researched by the MSSC: (1) Production; (2) Manufacturing Production Process Development; (3) Logistics and Inventory Control; (4) Quality Assurance; (5) Maintenance, Installation and Repair; and (6) Workplace Safety, Health and Environment

Figure 13

Stakeholders in a Nationwide System of Skill Standards, Assessment, and Certification for Manufacturing

The work of the MSSC is being carried out presently through federal grants and in-kind contributions from companies, educators, unions, and interest groups. In its initial stages (the next 3-5 years) of standards development, the piloting of assessment and certification tools, as well as marketing and systems building, the MSSC will need solid support from industry, the federal government, state governments, and foundations.

Building such a system in the U.S. for the first time is a complex process, and significant challenges will arise, especially during the initial stages of development, in gaining acceptance and commitment by all the relevant stakeholders.[54] Over time, however, this system should become increasingly self-sustaining on the strength of its value-added products and services to individuals, companies and communities.

[54] NACFAM, Proceedings of the AMLF Chicago Meeting, October 20, 1999, and Proceedings of the AMLF Detroit Meeting, December 7, 1999

Agenda Item 2: *Technical Training Tax Credits*

The federal government should adopt two corporate tax credits to encourage greater technical training. The first confronts the scarce supply of entry-level trained workers by providing a corporate tax credit of up to $15,000 per employee per year for those in early formal training or apprenticeship programs. The second addresses the need for lifelong skill maintenance by establishing a corporate tax credit of 50 percent of the cost of formal training for front-line, hourly wage workers, up to a maximum of $2,500 per employee per year.

There is a national interest in ensuring that American workers maintain their competitive edge in the global economy by continuous training on the skills needed to keep pace with technological change. This should apply across all sectors of the economy, including manufacturing, that make active use of advanced technologies. There are no tax incentives currently available to companies and workers to encourage introductory training or increase lifelong technical skills training.

A recent study by the National Association of Counties completed in 1999 found that 75 percent of the largest counties in the U.S. face a shortage of skilled workers.[55] Those shortages have increased in severity over the last five years as the unemployment rate of the nation has fallen. Manufacturers across the country face the dual problem of finding enough skilled workers and keeping the skill sets of the incumbent workforce up-to-date.[56] To address these two problems, a complementary set of tax credits is suggested.

To address the general problem of an unskilled entry-level workforce, the federal government should approve a corporate tax credit of up to $15,000 per employee per year for participation in early formal training or apprenticeship programs.[57] Apprenticeship and introductory training programs have become difficult for companies to sustain as competitive pressures have increased. The tax credit would encourage companies, in particular small businesses, to provide long-term training to unskilled workers.[58]

To help incumbent workers update their skill sets, the federal government should allow employers a corporate tax credit of 50 percent of the cost of formal training for front-line, hourly wage workers (entry-level through first level of supervision), up to a maximum of $2,500 per employee per year, in technical skills needed to increase employee productivity rates and reduce unit labor costs. Formal training must take place within the framework of an organized program supervised by qualified instructors and must go beyond informal, short-term, on-the-job training.

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[55] National Association of Counties, Skill Shortage in Large Urban Counties: A Survey on Impact and Response, (Washington, D.C.: National Association of Counties, 2000).

[56] NACFAM, Proceedings of the AMLF Chicago Meeting, October 20, 1999 and NACFAM, Proceedings of the AMLF Detroit Meeting, December 7, 1999.

[57] Legislation in the House and Senate (H.R. 1824 and S. 1291) would create such an incentive. These bills, however, are limited to a set of defined "highly skilled trades." This policy recommendation would loosen that restriction to cover the entire manufacturing sector.

[58] To qualify for the credit under the Skilled Workforce Enhancement Act (H.R. 1824 and S. 1291), the training program must be at least 2,000 hours of on-job and classroom training per year and the training program must be at least 2 years in duration. Employees have up to 4 years to complete the program.

Formal training may be located in various, bona-fide training settings, including on-site training centers, shop floor, voc-tech centers, community and technical colleges, joint company-union training facilities, certified commercial training centers, and may include established apprenticeship programs. These training regimes ultimately should incorporate skill standards, including those developed by the MSSC.

> ***"U.S. manufacturers can not find workers with the skill sets necessary for them or the company to compete successfully."***
>
> ***Paul Freedenberg, The Association For Manufacturing Technology***

It may be supplemented by training that uses advanced learning technologies, such as on-line training, distance learning, simulation tools, and virtual reality. Technical skills may include computer- and information-based, but may include both hardware and software applications. They would include, for example, skills needed to improve productivity in the use of computer- and information-based systems related to programming, statistical process controls, machining, tool and die making, quality control, drafting and design, computer support, data processing, logistics and inventory control, assembly, invoicing, procurement, maintenance, installation and repair.

Inclusion in this tax credit of formal, on-site training using advanced technologies would also accelerate the trend towards "just-in-time" training, i.e., training made available where and when needed to acquire specialized skills. According to the Council on Competitiveness, "Best practice today focuses on providing on-demand training from desktop computers, promoting interactive learning on-site, and shortening the cycle of formal training courses."[59]

The system of tax credits also expands the set of businesses that would consider sponsoring training programs. Small- and medium-sized manufacturers have difficulty locating workers with the appropriate skills and, because of the expense of existing training programs, are forced to create ad hoc programs. A significant tax incentive would encourage these firms to send eligible workers to formal training programs, which could provide both the worker and the company with a higher quality experience.[60]

[59] Council on Competitiveness, Winning the Skills Race (Washington, D.C.: Council on Competitiveness, 1998): 11.

[60] NACFAM, Proceedings of the AMLF Palo Alto Meeting, February 29, 2000.

Policy Area 3:

ENHANCING THE PERFORMANCE OF SME SUPPLY CHAIN

Small and medium-sized manufacturing enterprises (SMEs) are having a difficult time adjusting to the pace and intensity of technological change in the modern economy. Pressures are growing as larger manufacturers increasingly outsource their manufacturing activities to first tier and second tier suppliers. Since SMEs are central to the well-being of the nation's manufacturing base, it is appropriate to consider potential public policy options that can facilitate their productivity and quality.

The economic significance of small businesses in the United States deserves reiteration. According to the Small Business Administration (SBA), "the economy's growth in the recent year is very much tied to the growth of small businesses:

- Over 19 million new jobs have been added to the economy since 1993.
- 3/4ths of all jobs are created by small businesses.
- The number of small businesses is growing rapidly in the United States – up 49% since 1982.
- Almost a quarter of U.S. households are either starting a business, own a business, or are investing in someone else's business."[61]

Inside the manufacturing community, the role of SMEs is just as significant (Figure 14). The 325,394 small and medium-sized manufacturers, i.e., firms with fewer than 500 employees, account for 98 percent all U.S. manufacturing firms, employ 7.1 million people (38 percent of total employment in the manufacturing sector), and account for one-third of the estimated receipts for all manufacturing.[62] These firms also serve as the principal suppliers to large manufacturers. They provide products and services that are critical to the efficient operation of the nation's 5,000 larger manufacturers (i.e., firms with more than 500 employees).

SMEs face several unique problems. First, they have difficulty accessing and applying new technologies and have very limited R&D capabilities. As a whole, SMEs adopt new technologies and techniques more slowly than their larger counterparts. Second, change in the manufacturing paradigm is straining the abilities of most SMEs to adapt. Driven by information technologies and strategic decisions by large firms to outsource more of their manufacturing operations, the role of SMEs in manufacturing in the 21st century is undergoing a radical transformation that will require them to be more technologically proficient and more responsive to changes in technology. Third, many SMEs are reluctant to embrace new technologies and processes because they are unaware of or are unconvinced about the positive impact the introduction of those technologies may have on their business.[63]

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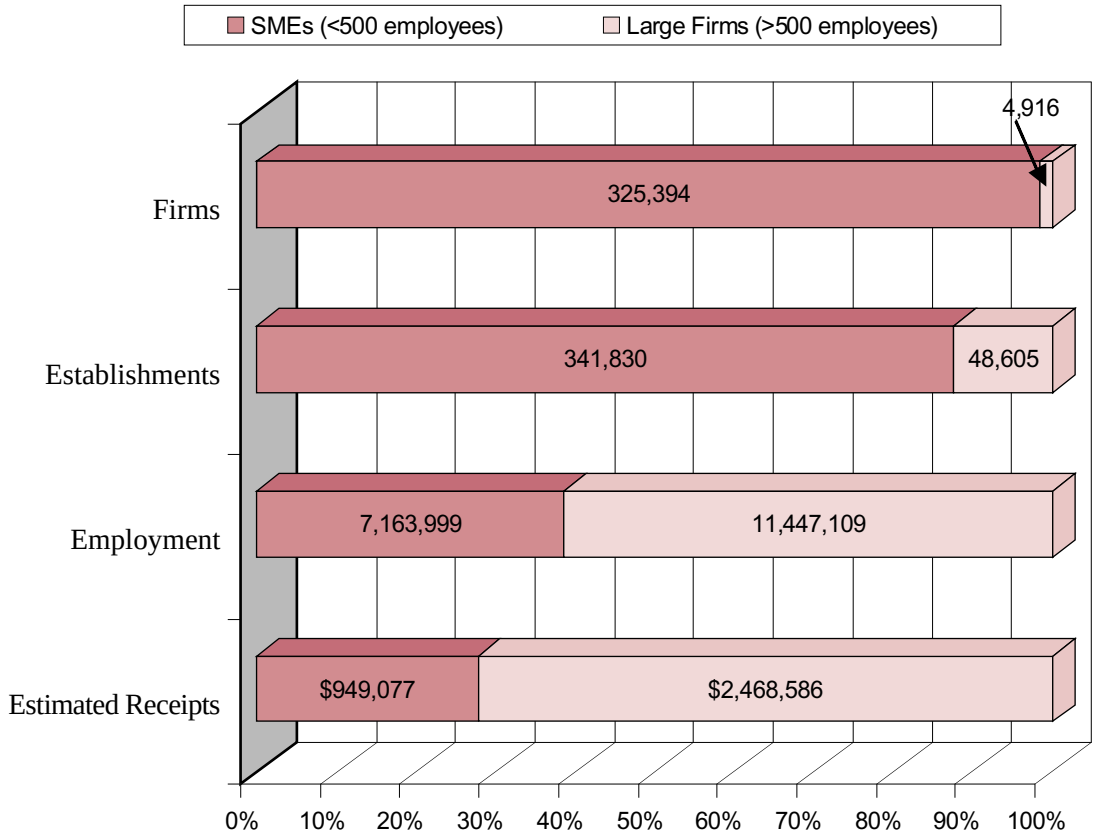
[61] Aida Alvarez, Administrator, U.S. Small Business Administration, Speech before the National Press Club, Washington, D.C., September 22, 1999.

[62] Data for 1995 from The State of Small Business: A Report of the President, (Washington, D.C.: Small Business Administration, 1997).

[63] NACFAM, Proceedings of the AMLF Chicago Meeting, October 20, 1999, and NACFAM, Proceedings of the AMLF Detroit Meeting, December 7, 1999.

Figure 14: Manufacturing Firm Characteristics, by Firm Size (1995)



Note: Estimated Receipts in Millions of Dollars.
Source: Small Business Administration.

Agenda Item 1: *Leverage the Manufacturing Extension Partnership (MEP) to Create a Robust Manufacturing Industrial Extension Infrastructure*

The Manufacturing Extension Partnership (MEP) needs to develop new services to ensure its continued relevancy to small- and medium-sized manufacturing enterprises. To accomplish this task, MEP must begin developing these services. Federal and state government must grant MEP greater flexibility to work with the private sector and put in place a new incentive structure to reward success.

The Manufacturing Extension Partnership Program (MEP) has done remarkably well with limited resources. The backbone of a national manufacturing extension system is in place, but expansion is clearly necessary to reach the remaining SMEs. Physical expansion of the system to effectively reach the bulk of SMEs requires additional financial resources as well as qualitative changes in the services offered to SMEs.[64] Two steps are suggested to meet this challenge.

First, the explosion of new public, nonprofit and private products and services aimed at the SME marketplace provides a challenge and an opportunity for MEP to improve its services to SMEs. The MEP centers can help increase SME awareness of these products and services. In some cases, the MEP centers can act as credible channel and or partner for delivery of these services. A critical component of this task is the development of a set of nationwide services so SMEs across the country can receive the same services at any MEP center. The set of central, nationally applicable services can complement specialized services individual centers may choose to provide.

To facilitate the evolution of the MEP "network" as an integrated and one-stop shopping source for public and private SME services, Congress, in collaboration with leading private sector experts, should study the legal, administrative, regulatory and budgetary barriers for both MEP centers and the NIST/MEP central program office to design, operate and respond to private sector and nonprofit organization partnerships aimed at improving the capacity of SME productivity growth and competitiveness. The study should consider the long-term effectiveness of the MEP organizational model and legal/administrative environment and assess alternatives if appropriate. Public-private partnerships require more flexibility and timeliness in government participation and response to MEP needs and private sector/nonprofit partnership opportunities.

Examples of these services may include the following:

- Web-based, on-demand information and services;[65]
- Adoption and implementation of new technologies and manufacturing processes;
- Supply chain integration, management, and optimization; and
- Use of advanced communications and transportation/logistic systems.

[64] NACFAM, Proceedings of the AMLF Palo Alto Meeting, February 29, 2000.

[65] NACFAM, Proceedings of the AMLF Chicago Meeting, October 20, 1999.

"As the survival of SMEs is being increasingly imperiled by converging trends in supply chain integration, technology, and logistics, which are resulting in dramatic increases in low cost, global competition, and substantial demands for investment, SMEs have unprecedented needs for state-of-the-art guidance at an affordable cost."

National Research Council's Committee on Supply Chain Integration

Providing new services to SMEs would significantly improve the productivity of the supply chain to larger companies or original equipment manufacturers (OEMs). By relating new services directly to the supply chain needs of OEM, these companies are more likely to support the MEP because they can easily see its value to their own operations. In turn, participating SMEs gain access to information and practices that are most useful and relevant to their interaction with OEMs.

Second, federal and state government should relax controls on MEP to afford them greater flexibility in structuring relationships with the private sector and institute an incentive system that rewards MEP for successfully expanding private sector support for their programs and services. One step in this direction would allow MEP the opportunity to enter joint ventures or other kinds of partnering arrangements with the private sector. This change creates an environment conducive to the growth and evolution of MEP. It also would allow MEP to respond more effectively and efficiently to the changing economic conditions faced by the SME community.

Another important step would be the adoption of a new matching formula designed to increase private sector participation and support for manufacturing extension services. Currently, the MEP is supported by a combination of federal funds (about $110 million), state funds (roughly equivalent to federal funds), and company-paid fees for service (roughly equal to two-thirds of federal funds).[66] The formula proposal considered rewards MEP for increasing fee income from the private sector without jeopardizing the existing public sector investment.

To help MEP raise fees for service, fees from OEMs would also count toward this match as long as the fees were for supplier improvement programs involving SMEs. With this formula, the MEP will continue to receive federal and state assistance, but can leverage additional public resources by providing services demanded and supported by the business community.

An expanded manufacturing extension infrastructure could provide new services to accelerate SME productivity growth. Focus would be placed in such areas as: Lean manufacturing processes; IT-based networking; Organizational development, including the effective use of human resources; Electronic commerce demonstration systems; Web delivery for on-demand information acquisition; and Standards to enhance quality. Additional resources would allow MEP to diversify the methods to distribute services to SMEs. In particular, Web-based, on-demand information and services can be especially effective in reaching the SME community.[67]

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[66] Under a proposal considered by the AMLF for a new formula, federal and state governments would match each dollar of company-paid fees over a cumulative $100 million raised by MEP centers for their services, up to a maximum of $50 million each from states and the federal government. Under this formula, total funding for MEP (federal, state, fees for service) would increase from the current level of $250-270 million annually to about $450 million, enough to build a robust extension service. Even with this increase, the program would still be less than half the federal and state funding for the Agricultural Extension Service (federal FY 1999 funding of $928 million).

[67] NACFAM, Proceedings of the AMLF Chicago Meeting, October 20, 1999, and Proceedings of the AMLF Detroit Meeting, December 7, 1999.

Agenda Item 2: *Develop a Voluntary Common Electronic Framework for Supply Chain Integration*

The private various stakeholders should take the leadership to build a industry-led voluntary common electronic framework for supply chain integration. The purpose would be to enable interoperability between IT systems without sacrificing the unique characteristics and advantages of proprietary systems.

Information technologies, including Web-based systems, are transforming the relationship between buyers and suppliers in manufacturing. An efficient use of IT within supply chains can significantly improve the responsiveness, quality and productivity of suppliers. It can build pathways to lean production. Lean production, in turn, is the precursor to fully flexible manufacturing—i.e., ability to produce lot sizes of one to each customer's specifications. Many different design, engineering, hardware and software systems are used within supply chains, and even within a single firm. The proprietary elements of these systems frequently result in multiple and frequently incompatible formats, creating an interoperability problem that undermines the potential benefits of IT systems. Imperfect information flows within supply chains prevent coordination and increase costs.

The costs of this barrier to interoperability are staggering. According to a recent study of product data exchange in the automotive sector, the inability to efficiently exchange product data through the automotive supply chain alone conservatively costs the industry $1 billion per year.[68]

A common framework would increase productivity across all the multiple functions of buyer-supplier interaction: design, product data exchange, prototyping, testing, security, ordering, financial transactions, etc. To facilitate the successful integration of subtier suppliers into the production systems of first tier suppliers and OEMs, the various stakeholders should work to build a voluntary common electronic framework for supply chain integration.[69] The purpose would be to enable interoperability between IT systems without sacrificing the unique characteristics and advantages of proprietary systems. This framework should be designed as a simple network model that can tie together all supply chain activities across multiple companies. Specifically, this effort involves the development of a common logical "language" or ontology allowing concepts to be discussed in the same fashion regardless of the unique attributes of the software platform.

There would be multiple stakeholders in this enterprise, including industry users, supplier groups, leading IT vendors, the National Institute of Standards and Technology, ANSI/ISO, university and lab research centers.[70] An industry-led, national collaborative effort is essential if an interoperable, scalable framework is to evolve. Government involvement can leverage discussion, offer test beds, and provide the necessary leadership to advance U.S. interests in international fora.

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[68] NIST, Interoperability Cost Analysis of the U.S. Automotive Supply Chain, March 1999 (Planning Report 99-1).
[69] The FY 2001 budget request includes a $4 million initiative for standards harmonization activities related to e-commerce. This recommendation is certainly consistent with this initiative.
[70] NIST points to its role in the development of STEP – Standard for the Exchange of Product model data – as evidence of its capabilities to bring together this community and create a consensus toward a common goal. Sharon Kemmerer, STEP: The Grand Experience, July 1999 (NIST Special Publication 939).

Informal preparatory meetings of stakeholders can determine locations, hosts and timing of meetings on this subject. As a public policy measure, the federal government should express its interest in supporting and participating in a common, industry-led effort to develop this framework. Federal activities could focus on technical assistance in standards development and representation of U.S. interests in international fora on standards issues.

The clear driving force behind this initiative has to be industry. Suppliers of software will need to reach agreement on the common language and agree to use it. Consumers of these software products hold the key to bringing these groups to the discussion. Companies that deal with product data, large and small, are the ones bearing the costs for the inefficiency of the present system. Consistent and vocal insistence that this initiative is the proper course of action by these companies should generate interest among software providers to join the process.

"Interoperability . . . is essential to the productivity and competitiveness of many industries because efficient design and manufacturing require the coordination of many different participants and processes that rely on a digital representation of the product."

Smita Brunnermeier and Sheila Martin, Research Triangle Institute

Conclusion

The Advanced Manufacturing Leadership Forum's (AMLF) efforts over the last year produced an outline of steps needed to strengthen the infrastructure on which manufacturing productivity growth depends. This series of steps, encapsulated in the six specific recommendations for action, are not the only things that can or should be done. Rather, they represent a set of "smart" first steps in our journey into the future.

The "Smart Prosperity" agenda for the future is not the responsibility of any single organization or group of individuals. Safeguarding the continued prosperity of the United States is the obligation of every citizen, every worker, every company, and every policy maker. Figure 15 outlines a matrix for the roles and responsibilities envisioned for federal, state, and local government, the private sector, and other organizations in the six AMLF policy recommendations.

Tasks are assigned in terms of "enabling" and "action" responsibilities.

- An "enabling" responsibility means that the recommendation calls on that organization to take definitive steps to get a program up and running, provide funding or supplemental resources, or otherwise offer leadership to a particular effort.

- "Action" responsibility implies that the organization is responsible for taking steps to exploit the opportunities extended by the enabling action. Organizations may be asked to perform research, set up training programs, use standards, or participate in consensus building, for example. In addition to building on the "enabling" efforts, these organizations have unique incentives to pursue steps consistent with those proposed in this Agenda on their own. They are encouraged to do so.

The basic research recommendation calls on the federal government to increase R&D funding, which is its "enabling" role. The recommendation also suggests a number of ways in which those funds might be distributed – to states to form manufacturing R&D institutes, to universities through grants or for centers, to industry as research contracts, to federal labs or to industrial research consortia. Each of these organizations are important contributors to the national research infrastructure and are expected to both support and benefit from the basic research recommendation.

The second recommendation calls for state governments to enact tax credits to defray expenses associated with collaborative research or explore other means to support this kind of activity. In support of this "enabling" effort, the institutions supporting the research infrastructure are expected to participate in the partnering efforts generated by the new state incentives.

Industry, government, and labor share responsibility for developing the workforce skill standards, assessment, and certification system. The federal government is now providing the necessary funding to sustain the MSSC, but state government, industry, and foundation support will be needed over the next several years to supplement resources available through fees for MSSC products and services. Actual implementation of this nationwide system will require the active participation of many other stakeholders as well.

The technical training tax credits recommendation requires the federal government to adopt the new credits. Following that initial action, industry, workers, and the technical education and training community will have to work together to implement an expanded training regime by setting up new

programs or expanding existing ones, incorporating new training techniques, and designing curriculum specifically for entry-level and lifelong learning.

Federal and state government are asked to modify the legal regime governing the MEP Program to allow greater flexibility into the system and establishing the possibility for increased public support if MEP centers can increase their fee-based income. The centers themselves have the most important implementation role. The recommendation challenges them to develop new, national services that are relevant and valued by the SME and OEM communities. Industry's role as the customer of MEP services gives it important responsibilities as well. OEMs are asked to consider MEPs as an option for improving the operation of their supply chains. SMEs are expected to consider MEP services when seeking assistance.

Finally, industry leadership is essential to building a solution to the data interoperability problem in e-manufacturing. To be successful, the relevant industry stakeholders will have to reach consensus among themselves on the best set of solutions to this complex problem. The federal government can not impose a solution on the private sector, but it can play the role of catalyst and honest broker, convening meetings to discuss the issue, providing technical support, and articulating the U.S. position internationally.

Together these six recommendations will put the U.S. on the road to "Smart Prosperity" by supporting the manufacturing infrastructure, stimulating productivity growth, spurring innovative ideas, offering new opportunities to workers, and helping small businesses. Making these investments in the infrastructure today will help create a prosperous economy for the future.

Figure 15
Roles and Responsibilities of the AMLF Recommendations

	Federal Goverment	State/Local Goverment	Industry	Universities	Technical Education	MEP Centers	Federal Labs	Industrial Research Consortia	Workers
Basic Research Investment	●	△	△	△			△	△	
State-Led Collaborative R&D Programs		●	△	△			△	△	
Workforce Skill Standards	●	△	● △		△				● △
Federal Training Tax Credits	●		△		△				△
MEP Enhancement	●	●	△			△			
Data Interoperability	△		●						

● = "Enabling" Responsibility

△ = "Action" Responsibility

Source: NACFAM

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Incorporated in 1989 and headquartered in downtown Washington, D.C., NACFAM is an industry-led, non-profit 501(c)(3) research, education and services organization. Its goal is to enhance the productivity and competitiveness of all tiers of U.S.-based manufacturing.

To that end, NACFAM provides leadership in building national policies, programs and services in fields closely related to productivity growth in manufacturing: research and development in production process technologies; related workforce education and training; and supply chain optimization.

NACFAM's strategy is to leverage the nation's public and private resources in these fields by building a community between industry and non-profit organizations that offer value-added services to manufacturers: university research centers; federal labs; community and technical colleges; and manufacturing extension services.

To guide its research agenda and help draw public policy inferences from this research, NACFAM established in 1999 a high-level Advanced Manufacturing Leadership Forum. Forum members and participants played a key role in the development of this report.

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