Congressional Research Service

Memorandum May 21, 2008

TO: Subcommittee on Investigations and Oversight, Committee on Science and Technology, U.S. House of Representatives
Attention: Ken Jacobson

FROM: John F. Sargent
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Resources, Science, and Industry Division

SUBJECT: The Global Competitive Environment, Drivers of Change, and Potential Implications for Federal Policy

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This memorandum is in response to your request for information on the influences that are reshaping the global competitive environment and potential implications for U.S. policy. Congress has maintained continuing interest in the nation's competitiveness due to its implications for U.S. economic growth, job creation, standard of living, quality of life, and national security.

Technology and innovation have been central themes in discussions about competitiveness, along with key factors such as the U.S. workforce (e.g., education and training, with an emphasis on developing scientists and engineers), business climate (e.g. economic, trade, tax, tort, regulatory, and intellectual property policies), and infrastructure (e.g., roads, bridges, ports, airports, energy generation and transmission, telecommunications, national research facilities and equipment).

Many analysts have observed that a variety of powerful influences have converged during the past two decades to reshape the global business environment. Underpinned by advances in information and communications technology, market-based economic reforms, and free trade agreements, globalization and the integration of the world's national economies have accelerated. Historically, the interests of private enterprises, universities, individuals, and other institutions were strongly aligned with the nations in which they resided. Global drivers of change appear to have partially decoupled the interests of nations and some of the institutions that reside within.

This memorandum is focused on addressing selected influences driving changes in the global competitive environment; how these influences have shaped, and may continue to shape, the global competitive environment; and some of the potential implications for federal policy. I hope this information meets your needs. Should you require any additional material or if you have any questions, please call me at 7-9147.

Past and Current Competitiveness Challenges

The competitiveness concerns of the late-1970s and early-1980s were driven largely by the emergence of strong Japanese competitors in industries such as steel, automobiles, machine tools, and consumer electronics. These were industries in which the United States had been the global leader for decades and which had played a major role in building the nation's economic strength and prosperity. Many of the competitiveness concerns were driven by the close relationship between the government of Japan and its companies, leading some to refer to them collectively as "Japan, Inc." There was a sense that U.S. companies (and by extension, U.S. workers) were, in part, put at a competitive disadvantage by this relationship. As Japanese companies gained market share at the expense of U.S. companies, some American workers felt the pinch as plants closed and jobs were lost.

The competitive challenge of that period largely pitted the United States, its workers, companies, and universities—all in it together—against Japan (and to a lesser extent European competitors such as Germany) across a broad range of technologies and industries. From a federal policy perspective, U.S. companies were seen as the vehicle through which the nation competed, and thus the federal response was focused on helping companies compete. This response was multi-faceted, and included expansion of federal research and development (R&D); programs to support development of generic and enabling technologies; tighter linkages between federally-funded R&D at universities and government laboratories and the needs of industry; initiatives to foster greater technology diffusion; efforts to increase the number of scientists and engineers; and trade negotiations to open Japanese markets. Nevertheless, there were a variety of dissenting opinions including those advocating an explicit industrial policy to advance technology development and support struggling industries, others who sought to close U.S. markets to some foreign products or impose levies, and some who believed that U.S. interests would be best served by relying on market forces rather than federal policies or investments.

Some analysts believe that the current competitiveness challenge is different in at least two fundamental ways. First, they argue that there has been some decoupling of the tight alignment of interests between the United States and its citizens on the one hand, and some U.S.-based companies, investors, and universities on the other. This decoupling appears to be happening not just in the United States, but to different extents in other nations as well. Second, these analysts assert while the earlier competitive threat was essentially posed by a single nation (Japan) and its institutions with strength across a broad array of technologies and industries, the new competitive environment is populated by large and small companies around the world, including conglomerates that span multiple industries and have competencies in a broad range of technologies, as well as smaller companies with strengths in high value-added niches. According to these observers, the United States is well positioned to prosper in this new competitive global environment; however, it may require a review and realignment of federal policies, programs, and investments focused on improving national economic strength and prosperity. With global companies making decisions on a daily basis on where to locate work and production, federal government policies may be more effective in this environment if they seek both to grow and support domestic companies and to attract high value-added work (manufacturing and services) of all companies, domestic and foreign.

Drivers of Change

Many business leaders and analysts believe that the global competitive environment is being reshaped by powerful new drivers, foremost among them the digital revolution and the addition of new nations to the competitive arena. Several of these drivers are complementary to, and reinforcing of, other drivers.

The digital revolution opens new labor pools and enables new business processes and models. The development and global deployment of affordable, reliable, high-speed digital computing and communications technologies—the digital revolution—has enabled emerging and less-developed economies to connect to the developed world and its businesses. New business models and processes have been developed that have enabled firms to digitize and decompose (parse, slice, break down) large and complex work processes into smaller elements. These elements can be assigned, digitally sent, and performed wherever they can be done most effectively, tapping global labor pools. Upon completion, the work elements can be digitally returned and re-integrated into a complete work product.

The digitization of knowledge work (e.g., software and applications development, product design, engineering, architectural design, accounting), the codification of work into rule-based procedures, and the speed at which skills training is developed and made widely accessible have allowed populations in less-developed and developing countries to acquire skills and compete for knowledge work. These factors have allowed some countries to bypass the traditional economic development process—formerly a decades-long advance from low value-added industries (primarily commodity manufacturing) to higher value-added industries (advanced manufacturing and services)—and move at least part of their economies directly to higher value-added knowledge work. Also, while the relocation of manufacturing activities (e.g., building factories, developing supply chains) is expensive and time consuming, the relocation of knowledge work can take place faster and with fewer resources (e.g., an office, computers, telephones and Internet access). As a result, a growing number of countries can support high value-added business activity, creating a far more dynamic market in the world's knowledge and service-based industries. However, the digital revolution has also raised concerns about potential loss of privacy, identity theft, protection of intellectual property, and the effects of the commoditization of skills on U.S. workers. These concerns may act as impediments to globalization.

Economic reforms bring more nations, competitors, workers, and consumers into the global arena. Many nations around the world have embraced trade, undertaken free market economic reforms, and established the modern business infrastructure required to participate in global commerce. For example, some emerging economies have amended their national investment laws and established reliable financial institutions allowing capital to flow quickly to opportunities in their countries. As a result, the number of nations and workers that are able to participate in the global economy has expanded rapidly. Membership in trade organizations has increased from 23 countries in 1948 (under the General Agreement on Trade and Tariffs) to 151 today (under the World Trade Organization), significantly expanding the world's competitive arena. Notably, the governments of China, India, Russia, and Eastern Europe have embraced, to varying degrees, capitalism, free market economic principles, and entrepreneurship, and have taken steps to align national policies accordingly. In recent years, formidable new corporate competitors have emerged in these and other nations.

The addition of these countries to the global trading system effectively doubled the world's labor force.[1] This represents an unprecedented addition of productive capacity to the global free market economy, at the same time that knowledge and service work could be internationalized. While many of the workers in these nations are low-skilled, these nations also have large and rapidly growing pools of skilled and educated people who earn wages that, while high for their country, are far below the wages earned by American workers. Some have expressed concerns that the availability of these low-cost workers may adversely affect American workers through job losses and downward wage pressures. Corporations seeking to reduce labor costs may move knowledge work and/or production activities that are currently conducted by U.S. workers to other nations. While this may serve the interests of the corporation, some believe it may run counter to U.S. national interests. Others believe that offshoring (i.e., the movement of work to offshore locations) may serve the national interest by increasing market efficiency, improving the competitiveness of American-based companies, and reducing the cost of goods and services to U.S. consumers. In addition, some argue that such activities can improve standards of living abroad, increasing consumer demand and creating new commercial opportunities for U.S. companies and jobs for Americans.

American workers who lose their jobs as a result of globalization may require additional education and training to qualify for and secure new jobs. Some federal programs seek to provide assistance to these workers. For example, the federal Trade Adjustment Assistance (TAA) program is intended to help workers adversely affected by trade.[2] However, critics assert TAA has many shortcomings, including that eligibility is limited to workers who make "articles," effectively excluding service workers such as those engaged in information technology services (e.g., computer programmers, software engineers, database administrators) that have been among those most affected by offshoring. Some opponents of TAA assert that job displacement by foreign trade is no different than displacement due to other factors, such as domestic competition or automation, and therefore should not be singled out for special assistance. Others argue the program is ineffective; not well managed; and not focused on metrics of success (e.g., displaced workers securing new jobs).[3]

New forms of trade. Historically, international trade involved the transfer of goods across international borders. In recent years, alternative methods of delivering products to foreign markets— including sales through foreign affiliates and intrafirm transfers—have grown rapidly and are reshaping notions of international trade. In 2003, U.S. multinational corporations sold more than three times as much through foreign affiliates ($3.4 trillion) as through exports ($1.0 trillion).[4] In addition, growth in globally integrated supply chains has resulted in greater intrafirm transfers. Such related-party trade accounts for half of U.S. imports and one-third of exports.[5] Economists have long noted that pricing of goods in

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[1] Freeman, Richard, professor, Harvard University. *The Great Doubling: The Challenge of the New Global Labor Market,* August 2006.

[2] For additional information on this issue, see CRS report RL34383, *Trade Adjustment Assistance for Workers: Current Issues and Legislation*, by John J. Topoleski.

[3] Froning, Denise H. *Trade Adjustment Assistance: A Flawed Program*, Heritage Lecture #714, The Heritage Foundation, July 31, 2001.

[4] *Competitiveness Index: Where America Stands*, Council on Competitiveness, 2007.

[5] Eden, Lorraine, associate professor, Texas A&M University. *Transfer Pricing, Intrafirm Trade,* (continued...)

intrafirm transfers may be affected by corporate efforts to reduce taxes and tariffs, and thus distort trade statistics and assessments of national competitiveness. This, in turn, may make it more difficult to determine how to align policies, programs, and investments to foster U.S. competitiveness and economic prosperity.

In addition to the large multi-national trade agreements, nations have also established and continue to negotiate regional and bilateral trade agreements with unique, and sometimes preferential, treatment of signatories. However, supply chains in the new global business environment often span national borders, and can involve countries that are part of a bilateral or regional agreement and those that are not. As intermediate and end-products that incorporate components from multiple countries cross national borders, questions can arise as to which trade agreement or agreements might apply in any given instance. In a larger context, increased globalization may challenge the viability of the current global trade framework.

Countries may also be challenged in finding pathways to serve both national interest and corporate interests. For example, U.S. export control policies seek to protect national and homeland security by restricting some foreign access to products, software, and technologies (including technical knowledge) that have military or dual-use purposes. In today's globalized business environment, corporations are tapping capabilities and locating work and manufacturing capabilities to maximize corporate interests (e.g., to reduce costs, reach markets, improve innovation, tap best-in-class suppliers), sometimes in nations that the United States government may view as potential adversaries. To fully utilize these global capabilities, companies often move products, software, and technologies across borders. Such transfers—even when conducted solely for commercial business reasons—may be deemed contrary to U.S. national interests under export controls laws and regulations. Conflicts between national and corporate interests have emerged in fields such as semiconductors, encryption, and nanotechnology.

Rise of foreign scientific and technological capabilities. There is general agreement that the United States remains the global leader in science and technology.[6,7] The United States continues to lead all other nations in funding of R&D. In 2004, the United States invested more than 2½ times as much as the second largest conductor of R&D (Japan), and more than the rest of the G-7 countries combined.[8] Many nations, however, have recognized the important role technological leadership has played in economic development and have increased their public investments in R&D. For example, according to the Organization for Economic Cooperation and Development, China's rapid expansion of R&D was expected to propel it ahead of Japan in 2006, to become the world's second largest investor in R&D.[9] In total, foreign R&D investments have grown faster than those of the

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5 (...continued)
and the BLS International Price Program, July 2000.

6 *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, The National Academies, 2007.

7 *Competitiveness Index: Where America Stands*, Council on Competitiveness, 2007.

8 *Science and Engineering Indicators 2008*, National Science Foundation, 2008. [www.nsf.gov/statistics/seind08/c4/fig04-15.xls]

9 *Science, Technology, and Industry Outlook 2006*, Organization for Economic Cooperation and (continued...)

United States, reducing the U.S. share of global R&D from 69% in1960 to approximately 33% in 2002, even as U.S. R&D quadrupled in real terms.

Nevertheless, while rapidly developing nations may invest substantial capital in R&D, the efficacy of a nation's R&D investment in producing commercially viable technology and economic returns depends on a variety of other factors, including: the quality of the researchers, scientific and technological infrastructure, alignment of R&D with market needs, and the strength of linkages between academia and industry. In addition, developing nations may lack key elements needed to fully capitalize on viable technology, such as: a mature industry, service, and private capital infrastructure; experienced managers, entrepreneurs, and other business professionals; and/or a market-oriented business climate.

Many nations have also focused on increasing the number of scientists and engineers through targeted education efforts. As a result, some assert there are more scientists alive today than ever in human history.[10] Record levels of global R&D funding supporting work conducted by (possibly) record numbers of scientists and engineers may suggest that the scope and pace of innovation will continue to increase. One indicator of increased innovation is the number of patent applications to the U.S. Patent and Trademark Office. From 1956 to 2006, the number of U.S. patent applications grew by 467% while U.S. R&D grew 669% in constant dollars. During this period, the number of patents granted to foreign residents increased by 1313%.[11] In addition, for many industries, product development cycles have shortened and time-to-market has emerged as an important factor in competitiveness. An accelerated pace of innovation may lead to faster obsolescence as new products replace current ones more quickly. Increased knowledge diffusion may also lead to faster commoditization of products and knowledge. These factors could necessitate business models that extract maximum value from a new innovation in a shorter time. In turn, this may drive increased globalization as companies attempt to maximize customer reach. Alternatively, increased globalization could lead to economic and social disruptions that could lead some nations to respond with tariffs, subsidies, or other trade barriers.

Some believe that aligning federal policies with the demands the global economy puts on business may help to attract and retain high value-added activities. Others oppose a strong federal role in what they believe should be, fundamentally, a free market activity.

Globally Integrated Enterprises. Much media and policy attention has focused on "offshoring"—the movement of a company's business functions (e.g., information technology, accounting, customer service) or discrete work activities (e.g., developing a software application) to locations outside the United States, generally to reduce cost by tapping lower-wage skilled and semi-skilled labor—and its effects on U.S. jobs and economic growth. More recently, though, a new business model has emerged that takes a more holistic approach to accessing and integrating knowledge, expertise, capabilities, and

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[9] (...continued)
Development , 2006.

[10] Some assert that the number of scientists and engineers alive today is greater than the total of all scientists and engineers that previously existed throughout human history. See *Transformational Leadership*, lecture by former House Speaker Newt Gingrich, National Academy of Public Administration, November 21, 2003.

[11] U.S. Patent and Trademark Office website. [www.uspto.gov/go/taf/h_counts.htm]

other assets worldwide: the globally integrated enterprise. This model is described in the U.S. Council on Competitiveness' 2007 *Competitiveness Index* report:

> Enabled by digital commerce and the slicing of product and service processes, U.S. multinational corporations are adopting global sourcing and delivery strategies, creating product and service value chains that span the globe. With standard business processes and methodologies supported by a global infrastructure, U.S. multinationals serve markets, deploy capabilities, and employ resources in an ever-widening geographic arc. From R&D and production, to computer programming and customer services, global enterprises can locate business processes nearly anywhere in the world....
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> Activities along the global value chain have become increasingly disintegrated and allocated to those companies and locations best suited for each individual activity. Multinational corporations—and now, truly global enterprises—have played a critical role in this process, by investing abroad, by engaging new foreign suppliers, and by specializing in activities in which they have specific competitive advantages. They have created vast networks in which many small and medium-sized companies providing specialized inputs and services are directly integrated with global value chains.[12]

In this model, national borders are largely invisible to companies as they seek to conduct work across their entire value chain where it can be done most efficiently and effectively. A wide range of factors that might affect corporate value-creation—e.g., cost, speed, flexibility, quality, innovation, service—are prioritized and assessed. Public policies (e.g., tax, regulation, tort, labor) and public assets (e.g., national laboratories and equipment) are incorporated in this larger context. Companies operating globally must also consider and address social, cultural, and demographic difference. This approach is summed up by IBM CEO Samuel J. Palmisano:

> Simply put, the emerging globally integrated enterprise is a company that fashions its strategy, its management, and its operations in pursuit of a new goal: the integration of production and value delivery worldwide. State borders define less and less the boundaries of corporate thinking or practice.[13]

Some assert that the interests of U.S. multinational corporations (MNCs) and U.S. small and medium-sized enterprises (SMEs) have diverged as well. For example, there has been wide media reporting of a rift within a large manufacturing trade association between some MNC and SME members with respect to public policies the organization should advocate for. Once reliant primarily on U.S. SMEs as critical elements in their supply chains, globalization has created new options for MNCs, and some have replaced U.S. SMEs with suppliers in other countries. As a result, some SMEs have faced deep revenue losses, temporarily or permanently closing down operations. Some SMEs have benefitted from globalization by becoming part of the supply chains of non-U.S. companies. Others have benefitted by using new services, technologies, and transportation systems to serve customers around the world; previously such markets could only be served effectively by MNCs with extensive global sales, marketing, distribution and transportation infrastructure.

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[12] *Competitiveness Index: Where America Stands*, Council on Competitiveness, 2007.

[13] Palmisano, Samuel J. "The Globally Integrated Enterprise," Foreign Affairs, May/June 2006.

Potential Implications for Policy: Issues for Consideration

Competitiveness has been an abiding interest in Congress for decades, and remains so today. In recent years, Congress has held hearings, debated the merits of different approaches, and enacted legislation (e.g., the America COMPETES Act, P.L. 110-69)[14] to foster U.S. competitiveness and prosperity. If Congress chooses to further explore and address competitiveness issues, it may be useful to consider the policy implications of trends that have reshaped—and continue to shape—the global competitive environment. This section provides a discussion of selected areas for consideration. Some challenges identified in this section may be addressed in the near term through non-formal processes; others may require more extensive discussion, analysis, and changes requiring legislation.

Federally-funded Research and Development. Congress funds R&D for a variety of purposes including: specific concerns such as national defense, health, safety, the environment, and energy security; advancing knowledge generally; developing the scientific and engineering workforce; and strengthening U.S. innovation and competitiveness in the global economy. Most of the research funded by the federal government is in support of specific activities of the federal government as reflected in the unique missions of the funding agencies.

In light of the changed competitive environment and concerns about U.S. technological leadership and its implications for competitiveness, Congress, through its authorization and appropriations processes, may elect to consider the way R&D funding decisions are made. In doing so, Congress may choose to explore issues involving adequacy of the investment and the balance of the portfolio with respect to a variety of factors, including for example, the relative apportionment of R&D funding:

- among basic research, applied research, and development activities;
- between proprietary and open research;
- between investigator-driven basic research and goal-driven basic research;
- among disciplines;
- between single disciplinary research and multi-disciplinary research;
- between defense and non-defense R&D; and
- among conductors of R&D (e.g., government, academia, and industry).

Development of a comprehensive, balanced national R&D budget is impeded in part by the process used by the Executive Branch for formulating an annual budget and the process used by Congress to authorize and appropriate funds. In the case of the Executive Branch, R&D funding is included within the overall budget development process of each agency in conjunction with OMB. The President's annual proposed R&D budget is essentially a summation of the R&D requests of each agency. At the same time, approaches such as President Bush's American Competitiveness Initiative (ACI) are intended to broadly influence R&D investments by targeting specific agencies for funding increases. In the case of the ACI, the Department of Energy's Office of Science, the National Institute of Standards and Technology, and the National Science Foundation were targeted in order to increase spending on physical sciences and engineering research and development.

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[14] For additional information on the America COMPETES Act, see CRS report RL34328, *America COMPETES Act: Programs, Funding, and Selected Issues*, by Deborah D. Stine.

The Congressional authorization and appropriations process also may not lend itself to the development of a comprehensive and balanced national R&D budget. For example, the House and Senate Committees on Appropriations each have 12 subcommittees, each with jurisdiction over an annual appropriations measure that provides funding for departments and agencies under that subcommittee's jurisdiction. To meet its appropriations mark set by the budget resolution, a subcommittee may alter funding levels between programs within an agency, among programs within a department, or among different agencies under its jurisdiction. This may lead to unintended results if a coordinated and balanced approach to federal R&D spending is determined to be advantageous to U.S. policy.

Thus Congress may want to consider whether the efficiency and effectiveness of the federal R&D budget in fostering national competitiveness might be improved by changes in the executive branch and legislative branch processes that contribute to the development and funding of a comprehensive and integrated R&D portfolio. Such efforts might be most effective in the near term through closer collaboration within and between branches in developing and funding the federal R&D portfolio. In the longer term, Congress might choose to consider more formal, structural changes to the processes. Also, while fostering U.S. competitiveness is one framework Congress might choose to use in structuring the R&D portfolio, alternatively frameworks could seek to maximize federal R&D's contribution to national security, energy security, or environmental quality.

Federal Support for U.S. Scientific and Engineering Workforce Development. Congress supports the development of the scientific and engineering workforce through a wide variety of mechanisms.[15] Many in government, industry, and academia have called for federal efforts to increase the number of U.S. citizens earning degrees in science, technology, engineering, and mathematics (STEM) as a competitive response to the perceived increased technical capabilities and industrial competitiveness of other nations. Others express concern that past and projected demand for scientists and engineers does not suggest the need to increase the number of U.S. students earning STEM degrees, broadly, though acknowledge a case may be made for increases in specific disciplines.[16] Congress expressed its intent in the America COMPETES Act which authorizes a variety of initiatives intended to increase the number of students choosing to pursue STEM education, including new programs to increase the number of STEM teachers and to improve the knowledge and skills of current STEM teachers. While there is disagreement about the need for a broad increase in the number of STEM graduates, there is a broad consensus on the need for students pursuing such degrees to acquire additional non-technical skills.

U.S. graduates with STEM degrees will join a rapidly growing global pool of scientists and engineers. While it remains to be seen if graduates of foreign educational institutions have the same degree of expertise provided by U.S. colleges and universities, China and

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[15] These mechanisms include: scholarships, loans, grants, work-study and co-op programs, fellowships, traineeships, internships, funding of university-based research, summer institutes at national laboratories, and support for teacher professional development and curricula development.

[16] See testimony of Michael S. Teitelbaum, Vice President of the Alfred P. Sloan Foundation, before the Subcommittee on Technology and Innovation, House Committee on Science and Technology, hearing on "The Globalization of R&D and Innovation, Pt. IV: Implications for the Science and Engineering Workforce," 110th Cong., 1st Sess., November 6, 2007.

India (with populations 4.4 and 3.7 times larger than the United States) have focused on increasing the number of students graduating with STEM degrees. Currently, scientists and engineers in these and other developing countries earn a fraction of the wages earned by scientists and engineers working in the United States. Facing less expensive competition, U.S. scientists and engineers may need to offer greater value to employers or, alternatively, face downward pressure on wages or lost jobs. Thus, Congress may elect to consider whether and how federal programs and initiatives might be modified to increase the capabilities and productivity of U.S. scientists and engineers. Such efforts might include an assessment of:

- the types of work performed by graduates with STEM degrees,
- the knowledge and skills needed in each line of work,
- the knowledge and skills imparted through current STEM degree programs,
- the ability and inclination of educational institutions to receive and adapt to market signals about changing knowledge and skill requirements,
- the ability of the U.S. educational and training infrastructure to support the acquisition of new knowledge and skills by scientists and engineers currently in the workforce, and
- the way federal education and training programs can assist unemployed U.S. scientists' and engineers' transition to new opportunities.

Based on these assessments, Congress may wish to increase funding for or modify provisions of existing programs, leave them unchanged, shift resources to more effective programs, and/or eliminate programs. While some believe federal policies can help shape the knowledge and skills of the U.S. workforce to be more responsive to future global opportunities, others believe that the most effective means to accomplish this is to allow market forces to shape individual choices.

Today, individuals with degrees in science and engineering work in a variety of capacities. For example, scientists and engineers work as employees, independent consultants, and entrepreneurs; conduct scientific and engineering research, develop products, and manage technology development; and are employed in non-S&E fields such as law, education, finance, and public policy. They work in laboratories, in corporate boardrooms, and on Wall Street. They work independently and in collaboration with other scientists and engineers (increasingly with those in disparate disciplines), business professionals, customers, and others, both in the United States and in nations with different languages, cultures, and business practices. The variety of knowledge and skills required to succeed in these environments suggests that educational approaches focused only on imparting technical knowledge and skills may be insufficient preparation for the opportunities and challenges ahead.

Some assert that universities, in general, lack mechanisms for receiving labor market signals, are slow to adapt to labor market changes, and resist efforts to become more responsive to labor market needs. Among the options Congress might want to consider to address these perceived shortcomings are ways to improve the responsiveness of federal STEM education programs to labor market signals; impart complementary business, management, communications, language, cultural, and entrepreneurial skills; and prepare STEM graduates for self-directed life-long learning needed to keep pace with changing knowledge and skill demands. Areas for review and analysis may include:

- establishment of tighter and more responsive feedback loops between educators/educational institutions and employers;

- cross-disciplinary education to exploit what many expect to be significant opportunities at the intersection of traditional disciplines (e.g. bio-informatics, bioengineering, microelectricalmechanical systems, chemogenomics);
- exposure to fields not generally a part of S&E education (e.g. cultural anthropology, data visualization, business, innovation, law, public policy, language, foreign cultures);
- methods of teaching (e.g., lectures, seminars, laboratory work, team projects, hands-on exercises, work-study, deep dives); and
- innovation-related knowledge and skills that facilitate the translation of knowledge into products, processes, and services (e.g., technology management, design, finance, manufacturing).

Some counter that during the period of rapid growth in the IT workforce in the late-1990s, the U.S. academic and training infrastructure responded rapidly and broadly to meet labor market demands; the universities' response, however, was hampered in part by the length of time required for creating and getting approval for new curricula. Others argue that universities are institutions of higher learning and should not serve the function of job training. In addition, some believe that this issue is best addressed between consumers (i.e., employers, students) and producers (i.e., universities), with little or no government involvement.

Retaining U.S.-educated foreign science and engineering graduates. In the era following World War II, many of the most gifted and talented students from around the world were attracted to the science and engineering programs of U.S. colleges and universities. Over time, the share of STEM degrees conferred by U.S. institutions to foreign students continued to grow. In 2005, more that two-thirds of engineering doctorates awarded by U.S. universities were awarded to non-U.S. citizens (62.2% to non-U.S. students with temporary visas; 4.7% to non-U.S. citizens with permanent visas).[17] For many years, a large number of those who graduated from these programs stayed in the United States and contributed to U.S. global scientific, engineering, and economic leadership. Today, many foreign students educated in the United States have economic opportunities in their home countries that did not exist for previous generations. Some nations are making strong appeals and offering significant incentives for their students to return home to conduct research and create enterprises. Thus, federal support for universities, in general, and scientific and engineering research activities, in particular, may contribute to the development of leading scientists and engineers who might return to their home countries to exploit the knowledge, capabilities, and networks developed in the United States. This may result both in the loss of value that might have been created in the United States as well as the development of firms, products, and/or services that compete against U.S. firms and workers.

Advocates for retaining these foreign graduates argue for the creation of new mechanisms or adjustments to existing ones to encourage some or all of these students to remain in the United States, including policies related to the number, length, eligibility, limitations, and conditions of temporary and permanent visas, and pathways to citizenship. Some analysts have suggested that the United States take a more targeted approach, focusing on identifying and retaining those most likely to contribute to U.S. competitiveness and other national needs. However, some opponents express concern that immigration preferences for

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[17] CRS analysis of published data; analysis excludes data for doctorates awarded to students for whom citizenship is unknown. *Science and Engineering Doctorate Awards: 2005*, Table 3, National Science Foundation, 2006.

science and engineering graduates may encourage foreign students without exceptional science and engineering talents to pursue S&E degrees for the primary purpose of gaining U.S. citizenship.

Creating an Attractive Business Environment. A variety of government policies, programs, and investments affect the environment for innovation, investment, and entrepreneurship, as well as the attractiveness of the United States to foreign firms to establish operations and/or conduct work. These include regulatory, tax, patent, tort, trade, labor, and immigration policies; and national infrastructure policies and investments (e.g., roads; ports; airports; bridges; telecommunications; and technical laboratories and equipment). An analysis of the nation's strengths and weaknesses in these areas with respect to growing, retaining, and attracting high value-added activities in the United States—especially in comparison to the policies, programs, and investments of other nations—might aid Congress in the development or consideration of legislation. In addition, an analysis of the criteria used by U.S. and foreign companies in site and work location decisions might complement this work. The breadth of policy areas and myriad of options preclude an exhaustive discussion in this paper. One or more of these topics could be addressed in greater detail by the Congressional Research Service upon request.

Concluding Observations

The convergence of influences is reshaping the global competitive environment. The number of countries, companies, and workers engaged in this competition continues to grow. New technologies, new business models, and broad adoption of market-based policies and free trade may have implications for federal R&D, infrastructure, regulation, taxation, and patent, tort, trade, labor, immigration and other policies. It is likely that the global competitive environment will continue to evolve with additional changes in technology, business models, national policies, and other factors. Congress may choose to consider mechanisms for monitoring, tracking, and assessing these changes; the policies, plans, priorities, strategies, and investments of other nations; the potential implications for federal policy; and the development of options Congress may consider in fostering U.S. economic prosperity and in addressing other national priorities.