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Industry Study

Final Report
Manufacturing Industry

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Manufacturing 2007

Abstract: The US manufacturing industry is the world's leading producer of manufactured goods. It is a significant driver behind the growth and prosperity of America's economy. On a global scale, if the US manufacturing industry were considered as a country by itself, it would rank as the eighth largest national economy in the world (National Association of Manufacturers [NAM], 2006, p. 5). US manufacturers are relevant, employing over 20 million Americans (directly and indirectly) and accounting for 15% of the US gross domestic product (GDP) (NAM, 2006, p. 4-5, 10). Manufactured goods also make up more that 60% of US exports and the manufacturing industry accounts for roughly 70% of US industrial R&D (NAM, 2006, p. 1). In addition to these contributions to our economic prosperity, US manufacturers strongly support national security by providing the foundation of our nation's defense industrial base. The Manufacturing Industry Study Seminar looked broadly at the manufacturing sector in the US. The Seminar assesses the US manufacturing industry to be competitive within the global economy, largely due to superior productivity and innovation. At the same time, the US manufacturing industry is facing challenges that threaten its competitive advantage in the global market. The three greatest challenges involve workforce demographics, structural costs (including government regulation), and future innovation. The Seminar visited several domestic manufacturing organizations as well as several in Russia and Germany to determine how the manufacturing industry is coping with these challenges. This paper provides options for the federal government to promote a successful future for US manufacturers. Additionally, this paper includes five essays focusing on topics that are significant to the manufacturing industry's support to national security. These topical essays cover trade policy, industrial continuity of operations, the environment, nanotechnology, and competition from China.

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Places Visited

Domestic

Caterpillar, Inc., Cary, NC
Center for Robotics and Manufacturing Systems, University of Kentucky, Lexington, KY
DHB Industries, Miami, FL
East Penn Manufacturing Co., Inc., Lyon Station, PA
Ex One Company, Irwin, PA
Extrude Hone Corporation, Irwin, PA
FPD Company, McMurray, PA
General Dynamics, Electric Boat, North Kingstown, RI
Goodwill Industries of South Florida, Miami, FL
Haas Automation, Inc., Oxnard, CA
Hamill Manufacturing Company, Trafford, PA
JWF Industries, Johnstown, PA
Kennametal Inc., Latrobe, PA
Mazak Corporation, Florence, KY
National Center for Defense Manufacturing and Machining, Latrobe, PA
National Institute of Standards and Technology, Gaithersburg, MD
Penn State Electro-Optics Center, Freeport, PA
Penn State Institute of Manufacturing and Sustainment Technologies, State College, PA
Space Explorations Technologies, El Segundo, CA
The Patten Company, Lake Worth, FL
Tompkins Associates, Inc., Raleigh, NC
Tooling Specialists Inc., Latrobe, PA
Toyota Motor Manufacturing, Kentucky, Inc., Georgetown, KY

International

Afghanistan Veterans Union, Yekaterinburg, Russian Federation
Center for Military Studies, Yekaterinburg, Russian Federation
Daimler Chrysler AG, Stuttgart, Germany
Eurocopter an EADS Company, Donauwörth, Germany
Heckler and Koch, Oberndorf, Germany
MTU Friedrichshafen GmbH, Friedrichshafen, Germany
Shurawi Museum, Yekaterinburg, Russian Federation
Urals Industry and Commerce Chamber, Yekaterinburg, Russian Federation
Ural State University, Yekaterinburg, Russian Federation
Uralmash Machine Building Plant, Yekaterinburg, Russian Federation
US Consulate General, Yekaterinburg, Russian Federation
US Embassy, Moscow, Russian Federation

Seminar Briefs

National Association of Manufacturers
National Science Foundation
US Department of Commerce

"Manufacturing is the backbone of our economy and the muscle behind our national security". -- Secretary Of Commerce Donald Evans

Introduction

At first glance, products such as bulletproof vests and automotive batteries may appear to have nothing in common. However, they share a vital characteristic—each one is a *manufactured* good. These items are but two of the thousands of manufactured items that led Secretary Evans to conclude "manufacturing is the backbone of our economy" (Department of Commerce [DOC], 2004, p. 5). The relevance of the US manufacturing industry is evident in its rich history, where it has repeatedly proven itself a staunch promoter of economic prosperity and national security. The 2007 Manufacturing Industry Study Seminar conducted a study to assess the industry's current performance, with special attention given to government policies and their effect on US manufacturers. The Seminar completed this appraisal through individual and group research, formal classroom training, and visitations to a diverse selection of domestic and international manufacturing firms. Additionally, the group called upon several federal agencies and educational institutions supporting the manufacturing industry. The group evaluated the manufacturing industry's ability to support US national security, including its ability to surge and mobilize to provide the Department of Defense (DOD) with manufactured goods in support of national defense interests.

This paper begins by defining the manufacturing industry and its importance to economic prosperity and national security. It then describes five significant conditions affecting manufacturers—productivity, technology and innovation, international competition, human capital, and government regulation. The Seminar identifies three major challenges affecting the manufacturing industry—workforce demographics, structural costs (including government regulations), and innovation. Looking ahead, the outlook and government role sections provide options to enhance industrial effectiveness to preserve national security and promote economic prosperity. This paper also includes five topical essays representing issues important to manufacturing, including trade policy, industrial contingency plans, environmental concerns, nanotechnology, and competition from China. Finally, the Seminar provides recommendations to government policies that can enhance industrial effectiveness to preserve national security and promote economic prosperity.

The Industry Defined

Manufacturing converts raw materials into finished goods through the application of labor, capital, and intermediate processes. The official definition of manufacturing comes from the Census Bureau's North American Industry Classification System, which classifies all business establishments in the US into categories based on how their output is produced. A business is classified as part of the manufacturing industry if it is engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products (Council of Economic Advisors, 2005, p. 73). In this paper, *manufacturing industry* refers to the collective group of companies that manufacture a wide variety of products ranging from raw materials such as steel, to those that produce highly finished products such as clothing, computers, and aircraft. As a result, the manufacturing industry provides the underpinning for a wide variety of other business sectors.

Our nation depends on the manufacturing industry to produce and sustain military weapons systems. Government policies and legislation such as the *Buy America Act* reflect the importance of the manufacturing sector to national security. Ideally, our national industrial base would be reliable, cost-effective, and capable of meeting strategic objectives (OUSD (AT&L), 2006, p. 1). In this regard, policymakers protect our industrial base by scrutinizing defense manufacturers' abilities to guard against security leaks, hidden design vulnerabilities, and malicious software codes since these threats could place US national security at risk (OUSD (AT&L), 2006, p. 3).

On a global scale, if we consider the US manufacturing industry as a country by itself, it would rank as having the eighth largest national economy in the world (NAM, 2006, p. 5). US manufacturers directly employ over 14.3 million people and create another 6 million jobs in related sectors (NAM, 2006, p. 4). In 2006, the manufacturing industry accounted for 15% of the US GDP, and it contributed over $1.5 trillion to US GDP in 2005 (NAM, 2006, p. 5, 10). It is easy to understand why the US manufacturing industry is considered a significant driver behind the growth and prosperity of America's economy.

Current Conditions

The US manufacturing industry is alive and well, leading the competition in the global economy. Manufacturers promote higher living standards for all Americans by creating superior products, paying high wages, and raising tax revenue for the government. The manufacturing industry continues to hold a major role in advancing our nation's economy. According to the National Manufacturing Institute, manufacturers accomplish this feat by investing in research and development (R&D), promoting high productivity, and paying high wages (NAM, 2006, p. 1-2). Manufacturers also serve as the foundation of our nation's defense industrial base and advance national security by producing state-of-the-art weapons systems enabling our military to maintain a competitive edge over would-be adversaries. The US manufacturing industry remains competitive within the global economy by embracing productivity, technology, and innovation while managing complex issues associated with international competition, human resources, and government regulation.

Productivity

Today, the US manufacturing industry produces more goods than at any other time in its history. In 2005, the net value of the US manufacturing sector, in terms of GDP, was over $1.5 trillion (DOC, 2004, p. 30). Increases in productivity, defined as the amount of goods and services produced after being adjusted for inflation, has been the spearhead of this achievement (DOC, 2004, p. 30). According to NAM, increasing productivity is a key contributor to both economic growth and a rising standard of living. Historically, manufacturing productivity has outpaced other sectors of the economy, rising 109% during 1997-2002 when compared with the overall economy's productivity increase of 53% during that same period (DOC, 2004, p. 14). Productivity enables the US to remain competitive in the global market. According to the Bureau of Labor Statistics (BLS), since 1995, only the Republic of Korea and Sweden have had higher productivity growth rates (BLS, 2007a, p. 3). In 2005, US productivity increased at a rate of 3.3%, which was 1.5% less than its average annual rate since 1979 (BLS, 2007a, p. 3).

The US manufacturing industry leads the world in the absolute level of labor productivity, both per hour and per employee (NAM, 2006, p. 16). This achievement enables US

manufacturers to pay higher wages and provide benefits to American workers, and yet remain competitive against international companies with low cost labor forces.

Technology and Innovation

Technology and innovation are the lifeblood of the US manufacturing industry. The President's Council of Advisors on Science and Technology (2004, p. 14, 20) found that innovation is vital to maintaining the historical upward progression of the standard of living in the US. In addition, they found that as the velocity of technology development accelerates, the interdependency between new research and manufacturing becomes vitally important. In 2004, the DOC (p. 7) reported the US manufacturing sector leads in innovation, accounting for more than 90% of all US patents registered annually. Examples of new technological applications include robotics, computer-aided design techniques, product-engineering systems, radio frequency identification, just-in-time inventory control systems, and nanotechnology (National Institute of Standards and Technology, 2006, p. 68). Technological innovations are significant because they lead to increases in productivity, which has been the prime driver of our nation's economic growth. Over the past fifty years, increases in productivity have accounted for half of US growth in GDP (Engler, 2006, p. 84). The US manufacturing industry is committed to maintaining America on the cutting edge of technology. It finances 60-70% of the $200 billion of annual private sector R&D investment (DOC, 2004, p. 14; NAM, 2006, p. 1). This investment enables the US to outpace global competitors in applying for both foreign and domestic patents (NAM, 2006, p. 23).

International Competition

Participation in the global economy is more important than ever for US manufacturers as the demand for manufactured products continues to grow. International markets present new business opportunities for US goods. Worldwide, manufactured goods account for more than 77% of global trade (NAM, 2006, p. 41). Domestically, US exports for 2005 totaled $900 billion, of which more than 60% were manufactured products (NAM, 2006, p. 41). Foreign manufacturers are competing fiercely in the global market. While the US is the world's largest manufacturer, in terms of manufacturing exports it ranks second behind Germany with China closely behind in third place (NAM, 2006, p. 41).

Global competitors sometimes employ questionable means to achieve a competitive advantage. Industrial espionage, reverse engineering, and unfair trade practices are among the illicit practices used to counter the US manufacturers' edge in technology and innovation. International legislation affords minimal protection because of the difficulty of enforcement.

US manufacturers retain a competitive advantage over international competitors through innovation and productivity. These factors are critical in allowing the US manufacturing industry to compete effectively against countries with much lower labor and structural costs. As an example, China and India are rapidly growing their economies, and competing in the global market by countering US superiority in innovation and technology with relatively inexpensive labor. The competitiveness of US manufacturers, therefore, hinges on their ability to innovate and increase productivity.

Human Resources

In 2006, the US manufacturing industry directly employed 14.3 million people and generated another 6 million jobs in supporting sectors (NAM, 2006, p. 8). America's baby boom generation is just beginning to retire, but has not yet contributed to an emerging shortage of experienced, skilled workers on factory floors. Human resources are a key concern for most manufacturing firms, especially in the skilled technical areas. In 2005, the Manufacturing Institute, NAM, and Deloitte Consulting conducted a survey in which 74% of respondents reported that a high-performance workforce is a key business driver (NAM, 2006, p. 29). A more recent study by *Aviation Week & Space Technology* finds 25% of aerospace workers and 33% of DOD civilian technical workers will be eligible for retirement in 2008 (Anselmo, 2007, ¶5). This study projects a shortfall of 41,000-87,000 defense engineers by 2010 (Anselmo, 2007, ¶12). These potential labor shortages extend across the manufacturing base, and if left unfulfilled, could threaten America's dominance as the world's leader in technology and innovation. The *Challenges* section elaborates further on these critical human resource issues.

Government Regulation (Subsidies and Trade Restrictions)

US government trade policy continues to evolve. Debate continues over the effectiveness of specific trade protection measures and responses to unfair trade practices. Recent US government trade policy has focused on addressing specific violations rather than broad protection policies. As an example, in March 2007, the DOC received a grievance from an American manufacturer that the Chinese government was subsidizing some paper products. In response, the DOC imposed countervailing import duties. A subsequent investigation determined that Chinese manufacturers were receiving subsidies ranging between 10-21% (Coated free sheet, 2007, p. 1). This adjudication reversed a 23-year-old policy of not assessing monetary penalties against non-market economies (Coated free sheet, 2007, p. 1). NAM applauded the federal government's intervention by stating, "The decision is a rifle shot action that allows Commerce to focus on specific areas of China trade that are unfair, mitigating pressures for across-the-board actions" (NAM Applauds, 2007, p. 1).

Challenges

The US manufacturing industry is exciting, dynamic, and globally competitive. The globalization of the world's economy continues to raise competition to unprecedented levels. It has opened doors to foreign competition in the domestic market and has given access to US manufacturers in emerging international markets. Our research indicates that the greatest challenges to surviving and prospering in the global market involve workforce demographics, controlling structural costs, reducing onerous regulations, and remaining innovative.

Workforce Demographics

One of the manufacturing industry's biggest challenges will be filling a projected shortage of skilled workers. America's low 4.5% unemployment rate and aging workforce are likely to exacerbate this shortage (BLS, 2007b, p. 1). The BLS estimates the US will have 5.3 million vacant skilled worker positions by 2010 (Vinas, 2005, p. 26). Within the manufacturing industry, *Kiplinger Forecasts* estimates by 2012 businesses will need 2 million more scientists and engineers and 2.4 million more workers with key manufacturing and production skills (Skilled Worker, 2005, p. 2). These shortages are already beginning to appear; in 2005, 90% of

manufacturers reported a moderate to severe shortage of qualified skilled production employees (Engler, 2007, p. 62). The shortfall is especially acute in skilled trades, for positions such as welders and specialized machinists, and has its biggest impact in durable goods manufacturing (Aeppel, 2005, p. A2; Ruiz, 2006, p. 10). Left unchecked, the shortage of skilled manufacturing workers in the United States is projected to worsen when the baby boomer retirements deplete the inventory of skilled workers. *Kiplinger Forecasts* estimates it will take about 3.3 million new workers each year—native-born or immigrants—just to replace the retirees (Skilled Worker, 2005, p. 5). Labor shortages will drive up wages and increase costs for manufacturers. In an AC Neilson survey, 60 of 94 manufacturers expect labor shortages to increase their costs by $50 million over the next five years (Vinas, 2005, p. 26-30).

Our visits to domestic manufacturers reinforced the industry's growing concern over the shortage of human capital, though these anecdotal observations indicate that the shortages are just emerging and regionally based. Many of these companies believe part of the problem stems from the younger generation's perception that manufacturing jobs require working in dirty, unpleasant working conditions for meager wages. While some jobs naturally require an industrial type of environment, such as welding, grinding, or smeltering, we visited many companies offering competitive salaries and clean working conditions. Companies such as Space Explorations Technologies, East Penn Manufacturing, Toyota, and Point Blank Body Armor use state-of-the-art manufacturing equipment in well-lit, clean, climate-controlled environments. Overall, the manufacturing sector pays an average of 23% more than service related industries (Lieberman, 2003, p. 1).

While our visits in Russia also highlighted demographic workforce issues, the German companies did not express the same concerns heard in the US. German companies credited partnership apprentice programs with local schools for attracting youthful talent. In addition, with expectations of long-term employment, the German companies provided significantly more training for their employees. In some cases, the training programs stretched over several years. This type of program ensures a steady supply of skilled workers for these German companies.

Structural Costs and Regulations

Structural costs and government regulations impose financial liabilities on the US manufacturing industry. The most substantial structural costs are associated with taxes, health care, and employee compensation. Government regulations impose financial costs upon American manufacturers via environmental protection requirements and affect free enterprise competition with export controls and trade policies.

Structural costs are very complex. Corporate tax rates can provide an example of one facet of this issue. US manufacturers consider corporate tax rates to be high and cite it as a primary factor affecting their decisions on where to locate their business (Hassett, 2007, p. 36). According to the American Enterprise Institute, the highest national corporate tax rates are those of Japan (39.5%), the US (39.2%), and Germany (38.9%), while the lowest national corporate tax rates are found in Ireland (12.5%), Iceland (18%), and Poland (19%) (Hassett, 2007, p. 37). While highly industrialized countries like the US, Japan, and Germany share this structural cost, it can place them at a competitive disadvantage to businesses willing to operate out of nations with lower corporate tax rates.

Other structural costs show up in employee compensation packages. Wages comprise approximately 70% of total compensation while benefits fill the remainder (GAO, 2006a, p. 5). Employee benefits include paid leave, retirement, and health insurance. US law mandates almost

one-third of worker benefits, including Social Security, Medicare, Workers' Compensation, and unemployment insurance (GAO, 2006a, p. 5). Despite legislation that has expanded health insurance and pension options for employers, these costs continue to weigh heavily on US manufacturers. For example, before a vehicle is even built, the price of a General Motors automobile includes $1525 in health care costs, while a Toyota vehicle includes only $200 (Motown, 2006, p. 21). Between 1991 and 2005, the cost increases for health insurance and retirement payments were the major reasons behind the rise in the cost of employee benefit packages (GAO, 2006a, p. 3). Once again, the US shares these costs with some other highly industrialized nations like Germany, but faces a competitive disadvantage from countries with lower labor costs.

Innovation

America's ability to innovate and its commitment to invest in R&D are the cornerstones of its global competitiveness strategy. Innovation involves the invention, commercialization, and diffusion of new ideas. At each of these stages, the prospect of reaping a reward motivates people to action (Council of Economic Advisors, 2005, p. 135). A 2005 study by the National Summit on Competitiveness (2005, p. 1) identified an alarming trend. It noted that international competitors are improving their ability to create and disseminate corporate knowledge. They accomplish this feat by exploiting new information technology to rapidly diffuse knowledge and expertise, both of which contribute to advancing their manufacturing capabilities. Presently, the combined R&D expenditures by the federal government, universities, and industries exceed the total spending of our two closest global competitors, Japan and China (Duga & Studt, 2006, p. G14). However, these nations recognize the value of innovation and are rapidly increasing R&D investments.

Our international visits highlighted the key role innovation plays in manufacturing. All of the German companies we visited emphasized the importance of product innovation to their success. Each company advertised the world-class capabilities of their product, not its price. By contrast, a struggling company we visited in Russia was notable for its lack of innovation in either product, process, or marketing. Product and process innovation will remain a key challenge for American competitiveness in today's global economy.

Outlook

The US manufacturing industry is bright as the globalization of the world's economy continues to provide unprecedented opportunities for growth. However, with these opportunities come concerns regarding the availability of human resources, future innovation, and the ability of US manufacturers to meet national security surge and mobilization requirements.

Human Resources

Competition for labor will likely extend to the future and become the most difficult short- and long-term problem for manufacturers. Personnel will likely continue to be drawn away from the manufacturing industry. The services sector already accounts for over 70% of the US workforce (DOC, 2004, p. 14). Additionally, recruitment and retention of skilled labor will be extremely challenging. Several of the manufacturers we visited are concerned with filling the labor gaps expected within the next decade as their large number of baby boomer workers reach 30 years of service and begin retiring. In the short-term, the recruiting and retention of skilled

labor is proving to be an issue. The BLS estimates the US will have 5.3 million vacant skilled worker positions by 2010 (Vinas, 2005, p. 26). By 2012, America will face a shortage of over 2 million scientists and engineers according to *Kiplinger Forecasts* (Skilled Worker, 2005, p. 2). In the long-term, 2015 to 2050, as the baby boomers retire, the availability of highly skilled labor will naturally decline. Inevitably, the manufacturing industry is in direct competition with other industries recruiting workers from the same, shrinking labor pool.

Future Innovation

As the Secretary of Commerce noted, manufacturing forms the backbone of the US economy and is the muscle behind US national security (DOC, 2004, p. i). According to Connecticut Senator Joseph Lieberman, every job in the manufacturing industry creates another 4.2 jobs in the broader economy (Lieberman, 2003, p.1). The Manufacturing Industry Study Seminar visited Toyota Corporation in Georgetown, Kentucky, where nearly 10,000 people report to work every day. These employees are part of a total 192,000 direct manufacturing personnel in the automobile and light duty truck market (Employment and Training Administration (ETA), 2007, p. 1). This market drives an additional 6.6 million jobs responsible for contributing $243 billion to the US GDP (ETA, 2007, p. 1). These exceptional statistics are expected to continue through the innovation in American manufacturing.

The US continues to lead the world in manufacturing output, accounting for 25% of the global contribution (NAM, 2006, p. 6). As previously noted, the US continues to lead in innovation and productivity. For example, one company we visited, East Penn Manufacturing, invented an innovative lead-acid battery reclamation operation capable of recycling almost 100% of expended batteries (East Penn Manufacturing, 2003, p. 1). The company takes pride in the fact that in spite of global competition it continues to provide family-sustaining wages and benefits for their 5,000 employees.

Innovation in new product development, the beginning stages of the manufacturing process, is also alive and well in the US space industry. At Space Explorations Technologies Corporation (SPACEX) in Los Angeles, California, the company's business strategy is to create low-cost, liquid-propelled rockets to deliver over 9,000 pounds of payload into low earth orbit at one-third the current cost. Haas Automation Corporation in Oxnard, California, has innovated through computerized robotics that run two fully automatic, "lights out" shifts each day—increasing productivity and reducing costs along the way. These examples represent continuing efforts by US manufacturers to innovate their products and processes to maintain global competitiveness. This ongoing creativity provides a positive indication that innovation in future manufacturing processes and product development will continue.

Surge and Mobilization

The US military has been conducting war operations continuously since October 2001—a longer wartime effort than World War II. However, the increased spending for operations has not induced a widespread mobilization of the nation's manufacturing base. During the past five years of military operations, most of the companies in the defense industrial base have responded exceptionally well to unforeseen requirements. For example, Point Blank Body Armor in Pompano, Florida ramped up production of bullet-proof vests to meet the needs of our soldiers in Iraq and Afghanistan, halting only to await delivery of raw materials—Kevlar fabric—from the nation's sole provider, DuPont Corporation. Although today every soldier needing a bulletproof vest has one, the bottleneck in Kevlar production highlights several impediments to surge and

mobilization as it relates to manufacturing. Similarly, another company we visited identified potential shortages of forged steel castings and high precision ball screws as risks to its manufacturing production line. In this case, the manufacturer increased its inventory of critical materials and built up large stockpiles to ensure continuity of operations in the event of future shortages.

The previous examples identify a critical impediment to defense related surge and mobilization in the US manufacturing base—the availability of raw materials. Production of defense goods to meet DOD demands has been largely limited to select raw materials and an ever-growing dependence on global suppliers. Because of the business implications, sub-tier manufacturers are often unwilling or unable to make capital investments, such as facilities and machines, to increase capacity to satisfy short-term surge requirements. Their concern is that once wartime demand wanes, the added infrastructure will create inefficiencies and reduce productivity. This concern was one reason DuPont hesitated to expand its Kevlar production line to meet short-term surge requirements.

The slow pace of defense acquisition system is a second impediment that handicaps our nation's surge and mobilization capability. It is the front end of the manufacturing process that presents a challenge. The Massachusetts Institute of Technology (MIT) noted as early as 1989 that low efficiency among white-collar workers was a growing concern to US manufacturing capability (Dertouzos, Lester, & Solow, 1989, p. 41). MIT's prediction is now a reality as it takes American car companies 200% longer to develop a new vehicle compared to Toyota (Ward, Cristiano, & Sobekk, 1995, p. 12). This front-end inefficiency has resulted in over 18% market share losses for US automobile manufacturers (Levy, 2006, p. 11). Similarly, the average defense weapon system development process takes over 10 years and costs taxpayer's 40% more than original estimates (GAO, 2006b, p. 3). Just as front-end inefficiencies have impacted US manufacturers, the long weapon development process could pose a strategic threat to US national security. The short- and long-term forecasts of US manufacturing do not provide foreseeable relief from these impediment.

Government Role

After considering the outlook of the US manufacturing base, we turn next to the federal government and examine what actions it can take to improve the future for the manufacturing industry. It is useful to look at government regulation and policies as weights being placed on a balancing scale. On one side, the government adds policies and regulations to benefit commerce or the broader community. However, on the other side we find intended and unintended repercussions that counterbalance the benefits. If the government does not use extreme care in developing and issuing policies, it might unbalance the scale in a harmful way. For example, in 2002 the government implemented a steel tariff to help support a struggling steel industry. While the steel producers benefited, the policy negatively affected a much larger number of US manufacturers that use steel because of the sharp rise in costs as the price of steel escalated (Arndt & Magnusson, 2002, ¶3-5). This example illustrates that balance is essential to the government's role in regulation. The Manufacturing Industry Study Seminar believes the US government should focus its actions to improve the manufacturing base in a three-pronged strategy aimed at addressing structural costs, labor, and innovation. These three categories capture the boundaries of the issues facing the industrial base and the government's proper roles and responsibilities.

Structural Costs

Looking at the first prong, structural issues affect both the cost and competitiveness of American manufacturing. The manufacturing industry is constrained by numerous regulatory requirements, such as workplace, product, and environmental safety rules. These government actions impose real compliance costs on American manufacturers (Popkin, 2003, p. 38). The government should coordinate better with the manufacturing industry to determine how much each new regulatory requirement adds value and how it will affect the industry's ability to compete in the global market. This partnership between government and industry would benefit by revealing secondary and tertiary effects of an intended policy. This information would help policymakers balance the benefits against any negative impacts before enacting new requirements.

The federal government also has a role in ensuring the industrial base is adequate and available to respond to a surge requirement caused by a national emergency or critical defense need. The government can accomplish this task by reevaluating the manufacturing industry's current ability to surge in critical segments of the industrial base. Once this assessment is accomplished, the government can proceed to adjust policies in order to increase or decrease this ability as desired. Specifically, to address this concern, the government should consider economic incentives to motivate companies to retain excess capacity and train additional personnel.

Labor Market

Personnel resources are vital to both surge and normal production, which leads to the second prong of our analysis: the labor market. As identified in the *Challenges* section earlier, this aspect of the manufacturing industry presents an opportunity for government assistance with nominal unintended consequences. Our visits to many domestic manufacturers revealed a common theme: the domestic labor market for skilled and unskilled workers willing to venture into manufacturing jobs is very tight. The federal government, in conjunction with state governments, can take powerful and synergized action to help. For example, the government can provide relief by changing immigration laws and visa policies with an eye towards increasing the availability of qualified workers. This approach echoes NAM's finding in its *Labor Day Report 2005*, which stated that government must "reform visa and immigration policies to attract those trained in math and science" (NAM, 2005a, p. 9). In essence, the manufacturing industry shares our findings that these types of changes can help address the worker shortage problem.

The government has other avenues available to it that extend beyond increasing immigration limits. It could also enhance the available workforce by educating the public on the technology advancements related to manufacturing jobs. It could demonstrate the challenges and rewards available to people with various levels of educational experience, from those with GED diplomas to those with advanced engineering degrees. Furthermore, the federal government could increase the number of people holding degrees or educational certification necessary for the manufacturing industry by using economic motivators, such as targeted tax credits or student loan repayment programs. Finally, the government could couple these recommendations with the Department of Labor's Trade Assistance Adjustment, which retrains workers displaced by off shoring.

Innovation

In addition to addressing structural costs and the labor market, the Government must consider the ability of the US manufacturing industry to remain on the cutting edge of technology. The third prong of our analysis is innovation, which, while driven by a number of sources, is primarily the reward reaped from investing in R&D. These investments provide companies with a competitive advantage over foreign firms. Advancements in technology lead to better products and processes, quicker time-to-market, and increased customer satisfaction. Innovation enhances productivity and long term economic growth (The Government-University-Industry Research Roundtable, 2004, p. 1).

The changes in the global economy are significant. International competitors are improving in creating and deploying new capabilities using information technology. They are able to disseminate knowledge and expertise rapidly, which enables them to advance manufacturing capability more quickly. Talent, technology, and capital are readily available through global networks (National Summit on Competitiveness, 2005, p. 2). It is important for the US government to recognize and support research and technology development to ensure growth of US jobs and innovation (NAM, 2005b, p. 1). A frequently proposed solution is to simply increase federal R&D funding and institute tax incentives. However, even if on-going budgetary constraints did not make across-the-board increases difficult, it is better to identify the long-term direction of industry and invest in selected strategic programs. Additionally, the federal government could dedicate funds towards sharing federally-funded innovations and technology advancements throughout the industry. This initiative would provide US manufacturers with the opportunity to leverage the benefits of existing federally-funded research programs.

Conclusion

American manufacturers are the world's leading producers of manufactured goods and the backbone of a strong US economy. The manufacturing industry helps drive the US economy, with productivity gains enhancing the quality of life for all Americans. Nevertheless, the industry faces a number of challenges, including structural costs (e.g., government regulation), the continuing demand for innovation, and a shortage of skilled workers. The US government and manufacturing industry must work together to meet these challenges in order to maintain our economic strength and national security into the future.

Globalization opens doors for new products and new markets while increasing competition for the manufacturing industry. To help domestic manufacturers meet the challenges of the 21st century, the US government should consider options to help with the structural costs, workforce, and innovation. The US should work closer with industry as it develops new regulation, while assessing the costs and needs for an industrial surge capability. To address the workforce challenges, the government should consider changes in areas like immigration to increase the labor pool, while working closely with states and educational institutions to improve critical workforce skills. Finally, the federal government should focus its R&D activities on selected strategic programs, while broadening the access to current and future federally-funded innovations and technology developments. These actions will allow the US to retain and improve its competitive advantage and remain a global manufacturing leader.

ESSAYS ON MANUFACTURING RELATED ISSUES

These essays reflect the personal research and opinions of the individual authors. They are intended to provide thought-provoking insights relevant to the manufacturing industry.

Essay # 1: US Government Policy and Manufacturing Exports

On January 30, 2007, President Bush visited the Caterpillar Corporation in Illinois to get a perspective of the US manufacturing industry. After his visit, he made the following assessment: "Our job in government is to put pro-growth economic policies in place that mean companies like Caterpillar, which do the right things, can succeed" (Bush, 2007, p. 2). In this context, it is relevant to examine existing government policies to determine whether they create conditions that promote the export of manufactured goods. This essay reveals the challenges confronting American exporters, assesses the government's performance in helping manufacturers overcome these challenges, and provides recommendations for improvement. Specific areas of interest include the international playing field, US trade policies, and the US export control system. It explains how President Bush's strong emphasis on bilateral trade liberalization since 2001 has positively affected manufacturing exports, but risks fragmentation of the world trading system. Additionally, a review of the export control system exposes an obsolete program that impedes the export of US defense products.

The International Playing Field

Historical overview of US trade policy. After World War II, the US was the major contributor to the creation of the current multilateral economic system, based largely on the 1947 General Agreement on Tariffs and Trade (GATT). Subsequently, the US has led eight successful rounds of negotiations, from the first round at Geneva in 1947, to the last successful Uruguay Round conducted between 1986 and 1994. In 1985, the US signed its first bilateral Free Trade Agreement (FTA) with Israel and began a bilateral approach towards trade liberalization. In 1989, it signed a second FTA with Canada, which was extended to include Mexico in 1993. This agreement evolved into the North America Free Trade Agreement.

Since the inception of the first FTA until the present day, the US government has elevated the importance of bilateral and regional approaches. Currently, the US has ten bilateral and regional FTAs in effect, three undergoing implementation, and another three waiting for Congressional approval (Schwab, 2007, p. 3). The US has not been alone in the pursuit of these types of policies. As a result, more than 300 bilateral and regional FTAs exist throughout the world. In Asia, the number of FTAs has risen sharply, from 57 in 2002 to 176 in October 2006 (Menon, 2006, p. 1). The major reason for this increase in bilateral or regional FTAs has been the slow progress at the multilateral level. With the Uruguay Round taking 8 years and the current Doha round beset with difficulties, many countries have chosen bilateral or regional agreements as alternative solutions for extending their free trade areas.

Results of this policy. The multilateral liberalization within the framework of GATT and the World Trade Organization (WTO) has led to substantial tariff reductions, but at different paces among participating countries. After the Uruguay round the average level of tariffs applied on industrial products was 3.8% for developed countries (3.1% for the US) and 12.3% for developing countries (Irwin, 2005, p. 217). FTAs have helped US manufacturing exports. In 2006, US free trade partners accounted for nearly one-half of the US manufactured goods

exports, but only 6% of the trade deficit (NAM, 2007, p. 6). During his visit to the Caterpillar Corporation, President Bush cited two examples from 2005 that illustrate how FTAs improve international trade: Chile has risen to become Caterpillar's fifth largest export market and Caterpillar's export volume to Australia has grown by 26% (Bush, 2007, p. 4).

In addition to reducing tariffs, bilateral and regional FTAs are more effective in strengthening enforcement of intellectual property rights and eliminating non-tariff barriers resulting from tax and regulatory policies. The negotiation of bilateral and regional FTAs continues to be part of US trade policy. In 2007, the Administration will continue to make strides in its multilateral, bilateral and regional trade liberalization efforts (The US Trade Representative, 2007, p. 1).

Risks of this policy and recommendations. As previously stated, the major reason for the proliferation of bilateral or regional trade liberalization is the slow progress of multilateral negotiations. Countries do not want to be left behind in the race for new markets, so the number of bilateral and regional deals has accelerated dramatically in comparison to multilateral ones. This snowball effect has affected the progress of multilateral negotiations. The President of the WTO stated, "Regional trade agreements can divert negotiating energy and resources from multilateral forum—which is particularly serious for developing countries with limited capacities" (Lamy, 2006, p.7). In the end, the shift in preference, described by Bhagwati (2005, p. 11) as a "spaghetti bowl," is fragmenting the world trading system and making improvements at the multilateral level more difficult. The US should decrease its priority on bilateral or regional FTAs, and direct more effort on successfully concluding the Doha round of multilateral trade negotiations.

The Defense Export Control System

The International Traffic in Arms Regulations (ITAR) implements US export control policy. It designates the Department of State as the responsible agency for authorizing the export of arms with the aim "that the foreign policy of the US would be best served" (22 USC, Chapter 39, Subchapter I, Sec. 2752). Every article on the ITAR's US Munitions List, which includes items ranging form firearms to combat aircraft, must be authorized by the Department of State before it can be exported.

The downside of the ITAR licensing process is that it requires considerable time and effort. According to Northrop Grumman, it took on average 57 days in 2005 for it to receive a license (Weinberger, 2006, p. 82). The US government established the ITAR more than thirty years ago to deny the Soviet Union access to advanced technology, but today it is becoming more of a hindrance. At a time of increasing collaborative research between multinational companies, industry work-share, and distributed global production of complex systems, this arms export control process poses a strong barrier to US manufacturers. Indeed, it provides an incentive for foreign purchasers to buy non-US products and technologies, putting US manufacturers at a competitive disadvantage in the global marketplace. Without reciprocity by other countries, ITAR restrictions are of limited value since similar goods can often be acquired from other sources.

The US should limit the scope of ITAR to a smaller number of critical products and technologies and coordinate closely with allies to ensure global commitment to these restrictions. Additionally, the US should streamline the approval process by establishing a license system for pre-approved goods, which will reduce the time of having to execute a transaction for each product. (*By Colonel Pierre-Edouard Adenot, Délégation Générale pour l'Armement, France*)

Essay #2: Troy Revisited

When the Greeks sacked ancient Troy, it was not the army outside the city walls that brought defeat, it was the Trojan's failure to detect the danger they carried into their city. Our nation has experienced similar occurrences, and like Troy, we have remained strong through the course of numerous wars and struggles. But we also have a Trojan Horse in our midst, waiting for the right moment when its hidden threat will be released. Unlike the original horse, the one in our country is a metaphorical beast constructed of business practices centered on lowering inventories, slimming down our supply-chains, and driving to reduce costs in ways that would make even Wal-Mart blush. Inside this horse is a hidden weakness that has the potential to bring our national prosperity tumbling down. Research studies indicate a general lack of concern and visibility on a risk that the industry can mitigate: continuity of operations when a manufacturer suffers a catastrophic loss. With hurricanes, fires and other such disasters commonplace, history has demonstrated catastrophic losses are more likely to occur than wars or international disputes.

The Trojan Horse In The Economy

Examples of this weakness abound. In March 2000, a lightning bolt struck near a cell phone microchip manufacturing plant in New Mexico, causing the plant to burn. The lightning strike caused cell phone manufacturer Ericsson to shut down operations for weeks and resulted in a claimed loss of over $500M (Aldred, 2000, ¶1). In 1999, an earthquake in Taiwan shut down Hsinchu Science Park, the single producer of a key component on laptop motherboards (Lynn, 2005, p. 1). Numerous companies, including Dell and Hewlett Packard, struggled to keep production lines afloat while they waited for the manufacture of these vital components to resume. During this time, the worlds' electronic manufacturing output dropped by over 7% (Lynn, 2005, p. 2).

In hindsight, Dell and Ericsson had inadequate continuity plans for the disasters they faced, and they suffered greatly for their poor management. Fortunately, they rebounded, but recovery is the exception rather than the rule. According to a KPMG study, 40% of firms that do not plan for worst-case scenarios fail to recover and go out of business within two years (ElAmin, 2005, ¶1). With this statistic in mind, manufacturers must clearly plan for the threat of business disruptions lurking within the Trojan Horse we have nestled in the US industrial base.

It is important to note that a *catastrophic disaster* from the viewpoint of a small manufacturer is not limited to what traditionally is known as an *Act of God.* Disasters can take the form of a cancellation of a program by the government. For example, cancellation of the Comanche helicopter program threatened several specialized suppliers (Biesecker, 2004, ¶1). Disasters can also occur when a manufacturer's plant is operating smoothly, but the surrounding infrastructure suffers damage. Intralox, a manufacturer of conveyor belts, experienced this type of disruption in 2005 when Hurricane Katrina spared its facilities on the Gulf Coast, but decimated its surroundings (ElAmin, 2005, ¶5). The company was unable to resume operations because of failed infrastructure, government curfews, and looting. Manufacturers without contingency plans incur a great risk that could lead to delays in restoring production and delivery, which will lead to a loss of customers and market share.

The Trojan Horse In Security

The economic impact of a disruption of production or the loss of a manufacturer applies equally to the realm of national security. As an example, in the case of nuclear submarine

manufacture, only two shipbuilders in the US can produce the major hull and system components (Department of Justice, 2001, p. 1). A loss of either one would affect our ability to produce these critical vessels in a manner supportive of the National Security Strategy. At the component level, the global marketplace often provides alternative sources, but the domestic manufacturing alternatives for critical parts are often limited. For example, an F/A-18E/F Super Hornet's engine relies on foreign sources for a considerable number of components. Of these, over 80% rely on a single US manufacturer as the backup domestic source (OUSD(AT&L), 2004, p. 23).

Leaning the global supply chain increases the concern of having a backup manufacturer for vital products. Many US manufacturers are involved with high technology or very specialized goods. The loss of one of these unique manufacturers could remove a vital product needed by other manufacturers. It is easy to comprehend how the threat of our Trojan Horse, comprised of lean inventories and cost reductions, can cause a severe ripple effect of catastrophes in the web of the US industrial base. If one manufacturer collapses, other manufacturers might follow as their production lines come to a screeching halt.

Keeping the Threat in the Horse

From the cloud of dust and smoke surrounding the terrorist attacks of September 11, 2001, companies have come to realize the need for business continuity plans. Industries have scrambled to prepare them, and the government, through the Department of Homeland Security (DHS) has supported them with guidance and sample plans (e.g., DHS, n.d., p. 1-10). These hasty attempts strive to keep the threat contained within the Trojan Horse that has emerged from our overly cost-focused business practices. Unfortunately, these continuity plans miss the mark for the manufacturing industry as they focus too heavily on data recovery in the services sector.

While data and services are important to our economic health and security, the country needs a manufacturing base to survive. The plans for the service and information industries assume business is mobile and can move from one location to another with nominal difficulty, if not relative ease. The manufacturing industry does not have the luxury of mobility because mills and production facilities have inventory and equipment not easily relocated or replicated.

Without a change in how industry approaches these plans, when the next severe natural disaster or catastrophe strikes, the threat of massive damage to both our economic well-being and national security will be released from the Trojan Horse. While the industry plays a vital role in developing a culture where these plans become routine, the government can play an equally important role.

The government should take the following actions: (1) publicize the urgency of having such plans by sharing data on the number of manufacturers that have failed after catastrophes such as hurricane Katrina, (2) assist companies financially with their disaster planning directly or through mechanisms like tax credits, and (3) mandate business continuity plans for government contractors.

Business continuity plans are necessary because they reduce the potential of suddenly being unable to produce, which thereby reduces the impact of disasters on national security. The government must encourage manufacturers to develop these vital plans. We can ill afford the consequences of not being prepared for the next major disaster. Releasing the threat within the Trojan Horse could jeopardize economic prosperity and national security. Businesses must improve their continuity plans as poor preparation places the US manufacturing industry and nation at risk. (*By Mr. Achille Broennimann, Department of the Navy*)

Essay # 3: The Environment and Manufacturing

The manufacturing industry has changed radically over the last 20 years, and rapid changes are certain to continue. The emergence of new manufacturing techniques, spurred by intense competition, will lead to dramatically new products and processes (National Research Council, 1998, p. 1). As the manufacturing industry moves forward, it faces many challenges to stay competitive. One such challenge is addressing new environmental regulations. Former Vice President Gore, an advocate on environmental issues, is calling for the adoption of new policies to curb global warming. Manufacturers face hard challenges as they attempt to comply with government regulations designed to protect the environment while working to provide high quality, cost effective products to consumers.

Global Warming

The increased carbon dioxide (CO_2) concentrations in the atmosphere by industrial activities such as fossil fuel burning and cement production are driving legislative and judicial action. The Supreme Court ruled that the Environmental Protection Agency (EPA) could regulate CO_2 and other greenhouse gases. In the Supreme Court's first case on the environmental issue concerning global warming, the justices voted 5-4 in favor of the EPA, allowing it to regulate tailpipe emissions, including CO_2 (Stricter Emission, 2007, p. 1). The court's decision will ultimately determine whether automakers are required to manufacture vehicles that emit less CO_2. If this is the case, automakers will have to speed the development and increase the production of hybrids and other alternative fuel vehicles.

Although the Supreme Court's decision may foster innovation in the automotive industry, it may have even more dramatic affect on other manufacturing sectors. The Supreme Court decision may force manufacturers to reduce CO_2 emissions in an attempt to slow down the greenhouse effect. Adopting lean manufacturing methods might be a solution for the manufacturing industry.

Lean Manufacturing

Lean manufacturing is a business practice that strives to eliminate waste while delivering quality products at the least cost to the manufacturer and customers (Lean manufacturing, n.d., p. 1). Lean Manufacturing provides an organization with the framework for implementing environmental management standards that increase the consistency, measurability, and preventive nature of environmental activities undertaken by the organization (Thornton, 2000, p. 108). It calls for the integration and management of environmental risk into manufacturing operations. As this integration takes place on the manufacturing floor, each member of the production staff is empowered with the ability to make decisions and perform activities that will contribute to pollution prevention and the overall environmental responsibility of the company. Manufacturers can use the elements of lean production to undertake a broad examination of the role that management systems, practices, and policies play in enhancing environmental efficiency (Rothenberg, Pil, & Maxwell, 2001, p. 229).

The EPA examined the relationship between lean manufacturing and the environment to identify opportunities for enhancing environmental protection. The study concluded that lean manufacturing produces an operational and cultural environment that is highly conducive to waste minimization and pollution prevention (EPA, 2003, p. 3). For example, lean manufacturing operations usually have a waste reduction strategy in place. Lean manufacturing

saves materials, water, and energy, and it reduces wasteful scrap and pollutant emissions to the environment.

Lean manufacturing directly affects DOD. Numerous DOD locations have implemented lean manufacturing to offset the environmental challenge facing their organizations. One example is Robins Air Force Base, Georgia, which implemented lean manufacturing in its hazardous waste management processes. The new hazardous waste management process reduced labor hours for handling hazardous waste by 15% by improving overall efficiency (EPA, 2003, p. 65).

Reverse Supply Chain

The reverse supply chain concept focuses on both ends of the product lifecycle to help overcome the environmental challenge of product waste. Currently, new product development dominates R&D activity with little emphasis on product disposal. Manufacturers should consider assessing the disposal phase of the product lifecycle as they may find rich opportunities for improving their environmental performance by recovering materials discarded by consumers (IBM, 2006, p. 39). For example, Nike recovers the rubber soles from recycled footwear and turns them into surface materials for playgrounds and other sports facilities (IBM, 2006, p. 40). Kodak and Fuji both remanufacture their single-use cameras after the consumer returns it to have the film developed (IBM, 2006, p. 40). Recovering product waste can literally be a "gold mine." In another example, one metric ton of electronic scrap from computers contains more gold than that recovered from 17 tons of gold ore (IBM, 2006, p. 42). The financial incentives for reducing or recovering waste materials are well worth investigating.

Cost benefits derived from reprocessing or recycling waste products should cause managers to adjust their business strategy. Efficient manufacturers might actually design products and processes that preserve the strength and integrity of the manufactured components to allow recovery and reutilization. Reviewing product lifecycles from back to front—starting first with an assessment of re-use, redistribution, and disposal—and then determining the manufacturing process may present opportunities for progressive businesses and governments to capitalize on the economic advantage of the reverse supply chain.

Conclusion

Environmentally friendly products are a growing concern for customers and legislative officials. Major automotive manufacturers have recognized the need to design capabilities that meet environmental requirements. Throughout the manufacturing industry, businesses are taking steps to address environmental challenges. Within the federal government, DOD should do its part by taking the industry successes and applying them to its own environmental challenges. It must ensure its manufacturing supply chain meets environmental regulations. Although enforcement of environmental laws is the EPA's responsibility, DOD could establish a method to reward contractors for innovation in improving the environmental performance of their manufacturing processes. In the face of today's focus on global warming, the US government must do its share to ensure the environment is safe for future generations. Policymakers can start by enacting win-win legislation that encourages manufacturers to be environmentally responsible. (*By Mr. Dwight Martin, Defense Information Systems Agency)*

Essay # 4: The Future of Nanotechnology

Typing nanotechnology in the Google search engine today produces 17 million hits, a twenty-fold increase from just two years ago. This increase demonstrates the growth of this field, which is defined as the control of matter on a scale smaller than 1 micrometer, as well as the fabrication of devices on this same length scale (Maynard, 2006, p. 1). The range of subjects includes chemistry, applied physics, materials science, and mechanical and electrical engineering. Nanotechnology presents significant challenges and opportunities to the manufacturing industry because of the risks associated with the technology and the potential gains that it might be able to deliver in the development of new manufacturing techniques.

R&D

The biggest concern involving the development of nanotechnology is maintaining the ongoing emphasis on R&D. The National Nanotech Initiative (n.d., ¶1) estimates that the US is spending nearly $4 billion annually to fund nanotechnology R&D. Large industry accounts for about half of that amount with the remainder split between smaller businesses and government. The federal government passed the 21st Century Nanotechnology Research and Development Act in 2003, which implements a National Nanotechnology Program (The White House, 2003, p. 1). The first objective of the program is to establish goals, priorities and metrics to evaluate federal nanotechnology R&D. Government involvement is a step in the right direction for developing nanotechnology as it alleviates some of the risk to private investors.

Estimates show that China exceeded Japan in total R&D expenditures in 2006, with expenditures falling behind only the US (James, 2007, ¶7). China hopes that its growing investment in nanotechnology will help the country capture a large share of what is estimated to become a $3 trillion global market in nanotech-manufactured goods. Breakthroughs in nanotechnology research and commercialization may also confer economic superpower status on the country that gains an early advantage in this cutting-edge technology (James, 2007, ¶2).

Investments in human capital are also required. Without the necessary flow of scientists and engineers to maintain innovation, other countries will soon surpass the US in innovative technologies. While those in government and industry associated with nanotechnology have acknowledged this need, there is not a comprehensive strategy to encourage students to enter the technical fields of study or apprenticeships in skilled trades. The 110th Congress is considering legislation to improve this situation (HR 363).

Potential Applications

The primary impact of nanotechnology to manufacturing is in the areas of nanomaterials and coatings, which are quite different from the manufacturing industry's traditional products. Examples include nanoscale fiber coatings that repel liquids, resist stains, and soften the feel of fabrics; tennis balls with a nanocomposite coating that retain inner pressure longer; and composite tennis rackets with improved strength and stiffness (Silberglitt, Antón, Howell, & Wong, 2006, p. 11).

The development of nanotechnologies will have a drastic impact on defense and national security. For example, the Army is experimenting with uniforms made of nanomaterials that incorporate built-in chemical and biological sensors, and may aid in monitoring an individual's medical condition. Nanotechnology will allow users to power electronic devices with more efficient batteries, smaller ones that have more endurance. Other applications such as securing

the country's borders with tiny sensors that can detect people, weapons, explosives and other threats could significantly improve national security. Nanotechnology can make it technically feasible to monitor thousands of miles of open borders with small and inexpensive devices. The transition of new and emerging nano-enabled technologies from the laboratory to commercial products is dependent on numerous factors. Challenges include: integrating the devices into products with characterized and reproducible properties; cost; scaling up the manufacturing or fabrication for commercial production; development of related technologies; market forces; and consumer acceptance of nano-enabled technologies (Silberglitt et al., 2006, p. 161).

Many of the products currently under development require massive investment in new production equipment and facilities. For example, the best state-of-the-art semiconductor manufacturing process involves lithography, which can produce components as small as 45 nm in size. New materials and production methods will be needed to further miniaturize electronic devices down to single digit nanometers. At this time, no one knows when the benefits will exceed the costs of developing nanotechnology. However, it is a known fact that modern semiconductor manufacturing facilities come with a hefty price tag of over $1 billion. The necessity for producers to recoup their development and research costs along with the high start-up costs could put nanoscale semiconductors more than a decade away (Silberglitt, 2006, p. 167).

Associated Risks

As with any new technology, a primary concern with developing nanomaterials is the protection of human life. "While emerging nanotechnologies have great potential for good, there are increasing concerns that the selfsame attributes that make them attractive will also lead to new risks to human health" (Center for Responsible Nanotechnology (CRN), 2006, ¶1). For example, the invention of asbestos yielded flame retardant capabilities that led to its enthusiastic use in many applications while its unknown detrimental effects on human health later led to expensive litigation and mitigation efforts. The negative effects of asbestos had a great deal to do with the size and structure of particles in the material. There is a similar, unknown risk associated with nanomaterials since the particles and structures are extremely small and behave in new ways (Maynard, 2006, p. 1). In addition to the possible health effects on individuals, there is also the current emphasis placed on the environment. In the early days, there was the ominous prediction of "gray goo" where self-replicating "nanobots" get out of control and destroy everything in their path (CRN, 2006, ¶24). While most scientists discount this scenario, we cannot ignore the possible detrimental effects that nanotechnology might have on the environment.

Conclusion

The development of nanotechnology manufacturing is an important national security issue for the US. More effort needs to be devoted to educate the American people on the level of effort, the potential positive benefits, and the safety measures used to ensure that nanotechnology helps keep our economy and military strength preeminent in the world. At the end of the day, nanotechnology is here. We want it. We need it. We just have to make sure that we apply the correct resources to the development while focusing on the future, the environment, and the requirements necessary to maintain a US competitive advantage. (*By Mr. Steve Romero, Department of State*)

Essay #5: China's Manufacturing Industry: Friend or Foe?

China's Rise in the Global Economy

Today, China wields tremendous influence with a burgeoning GDP that has grown nearly 10% per year since 1990 (Morrison, 2006, p. 1). Its manufacturing industry is akin to a fast-moving freight train; it has power, momentum, and a destination! In 2005, China's total trade exceeded $1.4 trillion, making it the third-largest trading nation behind the US and Germany (Bureau of East Asian and Pacific Affairs, 2007, p. 1). Total trade with the US was $285.3 billion, making China the third largest American trading partner (DOC, n.d., ¶1). The Chinese Communist Party (CCP) fosters this robust economy with policies favoring domestic industries and providing a competitive advantage in global markets. Accompanying China's robust economic growth is an increasing appetite for foreign products, which presents US manufacturers with an opportunity to feed this insatiable hunger.

China: A Fierce Competitor

In the 1970s, the CCP developed a vision for economic reform and competitive strategies that paved the way for China's rise in the global economy. Their first steps reallocated human resources from the suburbs and implemented new processes that sparked its rise in industrial productivity. However, the real brilliance behind China's success was the pursuit of foreign sales and investment. International trade allowed China to take advantage of its abundant low-cost work force and grab a substantial share of the market for labor-intensive goods. Today, China is rapidly catching up to the US in the manufacturing industry. The latest statistical data from 2005 indicates China's manufacturing revenue reached $1.2 trillion, which lagged the US by only 20% (NAM, 2006, p. 5). Looking ahead, Oxford Economic Forecasting estimates for 2010 indicate that increases in trade with China could reduce US manufacturing employment by 500,000 jobs, roughly 3.5% of the manufacturing work force (Britton, 2006, p. 19).

China obtains much of its technical knowledge from abroad, often by attracting multinational companies or through the exploitation of reverse-engineered products. Regardless of the means, China's ability to manufacture sophisticated goods at reduced costs has caused the demand for its exports to skyrocket. While enjoying a high volume of exports, China inhibits imports by subsidizing domestic firms, erecting tariffs, and maintaining artificially low currency exchange rates. While these practices are objectionable to US manufacturers, China relies on them to maintain a positive trade balance and generate substantial currency reserves.

Still trailing the US manufacturing industry in innovation, technology, and processes, China invests its excess currency reserves in capital growth and the acquisition of foreign technology. For example, in December 2004, Lenovo Group Limited, a computer company primarily owned by the Chinese government, purchased IBM's personal computer division (Morrison, 2006, p. 13). In June 2005, the China National Offshore Oil Corporation (CNOOC) made a bid to buy a US energy company, UNOCAL, for $18.5 billion, although strong opposition in Congress forced CNOOC to withdraw its bid (Morrison, 2006, p. 13).

Leveling the Playing Field

China's manufacturing industry exerts competitive pressures that force US companies to cope, adapt, and adjust. Many Chinese practices are legitimate, while others are self-serving and undermine the competitive spirit of a free enterprise system. The following five strategies provide approaches for US government policymakers and the manufacturing industry to create

equitable business environments by understanding and adapting to competitive macroeconomic factors such as economic, social, political, and demographic trends.

Strategy #1: Low cost leadership. US manufacturers should search everywhere for opportunities to reduce costs, starting with the procurement of raw materials and progressing through each subsequent step until delivery of finished products to consumers. The theory behind this approach suggests that firms with lower costs can offer products at reduced prices. Manufacturers can gain cost advantages through economies of scale, economies of learning, and improvements in process technology and design.

Strategy #2: Product differentiation. US manufacturers stand to generate a competitive advantage by developing products that stand out from existing ones. Innovation is the driver behind the creation of new and better products; ones that create strong demand because of better variety and quality. Unfortunately, innovation is not a readily available commodity. It requires investments in time, money, and personnel resources to research and develop new ideas. Personnel resources are scarce because of the shortage of college students pursuing technical degrees in the areas of math, physics, chemistry, and engineering. In 2006, President Bush proposed the American Competitiveness Initiative to preserve our country's leadership role in science and technology. If approved, it would "double investment over ten years in key Federal Agencies that support basic research in the physical sciences and engineering that have potentially high impact on economic competitiveness" (Marburger & Portman, 2006, p. 1).

Strategy #3: Can't beat them, then join them. Domestic firms must develop strategies to counter the increasing international competition. The National Intelligence Council (NIC) predicts the globalization of economies is irreversible (NIC, 2006, p. 1). Many US manufacturers have already expanded their organizations beyond our national boundaries by transforming to multinational and transnational businesses. These transitions have proven to be effective as they allow firms to share benefits existing in other countries. Consequently, US manufacturers should consider expanding abroad to leverage opportunities beyond our borders.

Strategy #4: Knowledge management and information sharing. New developments in information technology systems facilitate storing, managing, and sharing knowledge, all of which lead to competitive advantage. The Internet explosion and related technologies reduce barriers to entry and increase international competition. CNN reported recently, "China's booming Internet usage continues unabated, with the latest figures suggesting that as many as an estimated 110 million Web surfers are on the mainland" (CNN, 2006, p. 1). This global transparency presents an opportunity to leverage global communications systems to gain a larger share of China's domestic markets.

Strategy #5: Lobby for a fair competitive environment. In addition to lobbying for fair trade, the federal government must push for equitable currency exchange rates and stronger enforcement of regulations designed to protect intellectual property rights. Free and fair trade benefits all participants by virtue of the law of comparative advantage. However, since many of China's manufacturers are state-owned, the CCP establishes regulations that favor domestic firms over the potential for achieving benefits to the overall market. US manufacturers have little influence over these policies and rely on the US government to protect their interests. As an example, the Manufacturing and Services unit of the International Trade Administration is a key ally that advances US global competitiveness by shaping and implementing domestic regulations, legislation, trade policy development, and negotiations to expand market access and increase exports (International Trade Administration, n.d., p. 1). (*By Captain Ed Takesuye, US Navy*)

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