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Industry Study

Final Report
Manufacturing Industry

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MANUFACTURING 2006

ABSTRACT: Manufacturing is a crucial element to the United States (U.S.) economy. Every industry and individual American depends on manufactured products. A healthy manufacturing industry is essential to providing better jobs, fostering innovation, raising productivity, and achieving higher standards of living. America has long been identified as a world leader in manufacturing. In fact, the U.S. is the world's leading producer of manufactured products. Taken alone, America's manufacturing sector is large enough to represent the fifth-largest economy in the world. Additionally, the U.S. leads the world in innovation, accounting for more than ninety percent of all annual U.S. patents as reported by the Department of Commerce. Through innovation and the application of new technology, U.S. manufacturers have raised productivity higher than ever before. However, the U.S. manufacturing industry is being increasingly challenged by foreign competition, high employee costs, a shortage of skilled workers, and increasing energy costs. The Manufacturing Industry Study Seminar visited several domestic and international manufacturing organizations to determine how the manufacturing industry is coping with these challenges. Our visits ranged from small privately owned businesses to large international corporations with manufactured products ranging from batteries, circuit cards, automobiles and ships to body armor. This paper defines the manufacturing industry; discusses manufacturing's impact on economic growth; examines three broad forces influencing the manufacturing industry - globalization, competitiveness, innovation and productivity; and describes current conditions and challenges these factors create within the industry. With respect to these factors, this paper includes our seminar's outlook and recommendations aimed at maintaining a healthy and productive American manufacturing industry. Additionally, this paper includes six essays focusing on topics which we believe are significant to the manufacturing industry's support to national security. These topics are skilled labor shortages, surge and mobilization, innovation and technology, the manufacturing transformation, environmental balance, and international travel impressions.

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PLACES VISITED

Domestic Travel

Association for Manufacturing Technology, McLean, VA
Cubic Defense Applications, Orlando, FL
East Penn Manufacturing, Lyon Station, PA
Engineered Fabrics Corporation, Rockmart, GA
ExOne Company, Irwin, PA
Goodwill Industries, Miami, FL
Hamill Industries, Trafford, PA
Harris Corporation, Malabar, FL
Hyundai, Montgomery, AL
JWFI Industries, Johnstown, PA
Kaman Dayron Corporation, Orlando, FL
Kennametal Inc., Latrobe, PA
Keystone Enterprise Manufacturing Alliance, Freeport, PA
Lockheed Martin (Missile & Fire) and (Simulation, Training Support), Orlando, FL
Malabar Manufacturing, Malabar, FL
National Association of Manufacturers, Washington, D.C.
National Center for Defense Manufacturing and Machining, Latrobe, PA
National Council for Advanced Manufacturing, Washington, D.C.
National Defense Industry Association, Arlington, VA
National Science Foundation, Arlington, VA
Patten Company, Lake Worth, FL
Penn United Technologies, Saxonburg, PA
Point Blank Body Armor, Pompano Beach, FL

International Travel:

GE Healthcare, Beijing, China
Hansoll Vina Garment Factory, Di An, Vietnam
Honeywell Tianjin Factory, Tinajin, China
Hung Vuong Co., Ltd, HCMC, Vietnam
Mitsubishi Heavy Industries, Nagoya, Japan
Nike Factory, Dong Nai, Vietnam
NTK/NGK, Komaki City, Japan
OPV Pharmaceutical, Dong Nai, Vietnam
Phu My Power Plant, Phu My, Vietnam
Saigon Ship Building, HCMC, Vietnam
Scancom Furniture, Binh Duong, Vietnam
Toyota Motor Corporation, Nagoya, Japan
US Consul General, HCMC, Vietnam
US Consulate, Nagoya, Japan
US Embassy, Beijing, China
UTC, P&W Chengdu Aerotech Manufacturing, Chengdu, China
Vina Kyoei Steel, Ltd, Phu My, Vietnam
Yamazaki Mazak, Minokamo City, Japan
Yara, Phu My, Vietnam

INTRODUCTION

"A nation's standard of living in the long term depends on its ability to attain a high and rising level of productivity in the industries in which its firms compete." - Michael E. Porter

The United States (U.S.) has been, and continues to be, the world's leading producer of manufactured products. America's manufacturing sector alone is large enough to represent the fifth-largest economy in the world (*Manufacturing in America*, 2004, p.7). Using innovation and the application of new technology, U.S. manufacturers have raised productivity higher than ever before. However, the U.S. manufacturing industry is increasingly challenged by foreign competition, high labor costs, a shortage of skilled workers, and increasing energy costs. The Manufacturing Seminar visited several domestic and international manufacturing organizations to determine how the manufacturing industry is coping with these challenges. Our visits ranged from small privately owned businesses to large international corporations, with manufactured products ranging from batteries, circuit cards, automobiles and ships to body armor.

This paper defines the industry; discusses manufacturing's impact on economic growth; examines three broad forces influencing the manufacturing industry - globalization, competitiveness, and innovation and productivity; and describes current conditions and challenges these factors create within the industry. It presents our seminar's outlook and recommendations with respect to these factors in order to maintain a healthy and productive American manufacturing industry. This paper also includes six essays on topics significant to the manufacturing industry's support to national security: skilled labor shortages, surge and mobilization, innovation and technology, the manufacturing transformation, environmental balance, and international travel impressions.

THE INDUSTRY DEFINED

Manufacturing industries vary from those that transform raw materials into more refined forms (e.g., the steel industry) to those that produce highly finished products (e.g., food products, electronics, and automobile industries). The official definition of manufacturing comes from the Census Bureau's North American Industry Classification System (NAICS). NAICS categorizes businesses into the manufacturing sector if they are "engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products" (*Economic Report of the President*, 2004, p.73). The primary processes involved include casting, molding, forming, machining, joining, assembling, and free form or layered manufacturing.

MANUFACTURING'S CONTRIBUTION TO ECONOMIC GROWTH

Manufacturing is the largest contributor to U.S. economic growth, contributing 22 percent to gross domestic product (GDP) growth (28 percent, if software production is added) over the past decade. By comparison, the services sector contributed a distant 14 percent. While the U.S. economy grew at an average annual rate of 3.6 percent between 1992 and 2000, manufacturing's share grew faster at 4.5 percent (*Facts about Modern Manufacturing*, 2006).

A Changing Face: The U.S. is a fully engaged player in the global economy, but not without drastic changes in the manufacturing industry. Though manufacturing continues to account for 13 percent of U.S. GDP and nearly 11 percent of total U.S. employment, the composition of

American manufacturing has changed in the past half-century due to technological breakthroughs, shifting demands, and international competition (*Manufacturing in America*, 2004, p.14). In 1950, the three largest manufacturing sectors were food, primary metals, and motor vehicles. These have been replaced by chemicals, industrial machinery and equipment, and electronics which account for a third of manufacturing GDP (NAM website, 2006, p.3).

The Multiplier Effect: The manufacturing industry casts a wide net across many other industries. It spurs demand for raw materials, intermediate components, and services such as software, financial, legal, health, accounting, and transportation in the course of doing business. Manufacturing generates substantial economic activity through its use of intermediate goods and services during the production process. This is called the multiplier effect, and manufacturing's multiplier effect is stronger than in other industries. "Specifically, every $1 of a manufacturing product sold to a final user generates an additional $1.43 of intermediate economic output, more than half in sectors outside manufacturing" (NAM website, 2006, p.13). The multiplier effect also stimulates employment in other sectors. Specifically, every $1 million in final sales of manufactured products supports eight jobs in the manufacturing sector and an additional six jobs in other such sectors as services, construction, and agriculture (NAM website, 2006, p.14).

International: The U.S. is the world's largest exporter with 75 percent of all U.S. exports being manufactured goods. By comparison, American farmers export about $60 billion a year, the equivalent of only one month of manufacturing exports. Forty percent of exports are sent to neighboring North American Free Trade Association (NAFTA) countries. According to the U.S. Commerce Department, the manufacturing products most exported in 2005 were computer and electronics, transportation equipment, chemicals, and non-electrical machinery.

Productivity Growth: Manufacturing productivity growth consistently outpaces other U.S. industries. "Over the past two decades, manufacturing averaged twice the annual productivity gains of the rest of the private sector" (*Manufacturing in America*, 2004, p.14). This productivity advantage allows manufactured good prices to rise slower than service prices. "In the past 25 years, prices in the overall economy have increased more than 140 percent, while prices in manufacturing have increased only 60 percent" (*Manufacturing in America*, 2004, p.16).

The U.S. leads all countries in the absolute level of labor productivity, both per hour and per employee, allowing the U.S. to maintain its labor cost advantage over trade competitors despite higher wages and benefits paid to American workers (*Manufacturing in America*, 2004, p.19). As Princeton University economics professor Paul Krugman said, "Productivity is not everything, but in the long run it is almost everything" (Krugman, 1997).

Higher Compensation: Though average hourly earnings in the wholesale trade, finance, and service industries have exceeded manufacturing earnings in recent years, the average hourly compensation of manufacturing production workers remains higher than the average in all other industries (*NAICS 31-33: Manufacturing*, 2006). According to U.S. Bureau of Labor Statistics, manufacturing employees earned an average of $65,000 a year (2004) in total compensation (salary plus benefits, bonuses and Social Security contributions) while the average for U.S. employees in the remainder of the economy earned a total compensation of just $53,000. Manufacturing's higher compensation is based on benefits, rather than higher hourly wages.

"Manufacturing employees receive an average of $8.89 per hour in benefits versus $5.94 for non-manufacturing employees. On average, manufacturers contribute more per hour for health insurance, overtime and supplemental pay, leave, and retirement" (*Manufacturing in America*, 2004, p.17). Health care coverage by manufacturers is the highest in the private sector, with 84 percent of manufacturing workers receiving direct health-care coverage through employers (*NAICS 31-33: Manufacturing*, 2006).

Recession: Though mild, the 2000 recession hit the manufacturing industry hard. Manufacturing output fell six percent and employment dropped by 2.6 million manufacturing jobs. Recovery has been slow, and many manufacturing firms are still experiencing a shortage of skilled workers in the industry (NAM website, 2006, p.48).

Over half of the manufacturing sector has experienced an unprecedented 67 percent plunge in profits from historic norms. Most affected are durable goods industries - fabricated metals, machinery, electrical equipment/appliances and motor vehicles/parts, as well as chemicals in the nondurable sector. The majority of the drop is attributable to rising health care and pension costs, rising commodity and energy prices, and exchange rate adjustments (Leonard, 2005, p.1-2).

CONDITIONS AND CHALLENGES

This section describes the current conditions and challenges within the manufacturing industry in the areas of globalization, competitiveness, and innovation and productivity.

GLOBALIZATION – The economic flattening of the world has considerably impacted the worldwide manufacturing industry. In economic terms, international borders and nation-states have started to lose their importance as huge multi-national corporations, with revenues exceeding GDPs, redefine the global marketplace. Treaties, international organizations, and intellectual property rights are critical topics that must be addressed in today's globalized world.

Treaties:
Current Conditions: The U.S. is party to several treaties (bilateral or multilateral), aimed at promoting an environment that fosters free, open and fair competition. The North American Free Trade Agreement (NAFTA) with Canada and Mexico is an example of such an agreement that has produced increased revenues and a level playing field for the participants.

Challenges: Maintaining a free and open marketplace that encourages fair labor standards and environmental compliance in developing countries is critical, despite political and public pressures towards protectionism.

International Organizations:
Current Conditions: The key organization for international trade is the World Trade Organization (WTO). Originated in 1995, the WTO is the hallmark for global trade and has 149 participating country members whose members must comply with free and open trade standards (Cooper, 2006). Each member country has a representative who makes decisions, primarily by consensus with other countries (*Understanding the WTO*, 2006). Absent consensus, there is a process for voting as well as a process for complaints (Cooper, 2006).

Challenges: The Bush Administration has relied on bilateral, regional, and multilateral trade strategies to improve the U.S. position in the global economic market. Overall, the results are positive but it is a challenge to develop the right balance among these trade strategies for the future.

Intellectual Property Rights:
Current Conditions: Theft of intellectual property is a global problem and adversely affects the U.S. manufacturing industry. The U.S. Trade Representative (USTR) and the WTO act on behalf of U.S. manufacturers to protect intellectual property. The USTR uses various means that include "domestic trade law; regional initiatives in Europe, Asia (APEC), Latin America (FTAA) and Africa; [and] existing institutions, notably the WTO and the World Intellectual Property Organization (WIPO)" (*The Work of the USTR*, 2004).

Challenges: U.S. adherence to WTO rules renders the U.S. somewhat impotent with regard to enforcement of intellectual property rights. China failed to transfer Intellectual Property Rights (IPR) cases for prosecution from customs officials to Chinese prosecutors and the U.S., through the WTO process, sought from China further information about its actual enforcement attempts over the past four years (Stratford, 2006). China's response is pending (Stratford, 2006).

COMPETITIVENESS - The U.S. is faced with numerous challenges as the manufacturing industry strives to maintain its leadership position and thrive in a highly competitive global environment. Productivity gains have kept the U.S. in a dominant position in the global economy. However, during recent years, millions of jobs were lost, non-production related labor costs increased, and manufacturers were forced to "right size" their workforce to remain competitive.

Outsourcing/Job Loss:
Current Conditions: The manufacturing sector is continuing a long-term reduction in labor driven primarily by productivity improvements. The short-term loss of 2.5 million jobs between 2000 and 2003 was driven by "the failure of domestic demand growth to match productivity growth" (Baily, Lawrence, Levy & Sichel, 2004). Although outsourcing is most often blamed, over 22 million manufacturing jobs have been lost globally between 1995 and 2002, including China's loss of 15 percent. In addition, the U.S. manufacturing industry is having difficulty finding qualified people to fill available jobs. For a more in-depth look at the skilled labor deficit, please refer to Essay #1 – *Skilled Labor Shortage*. Essays are located at the back of this report.

Challenges: The primary challenge faced by the U.S. will be to maintain world leadership in productivity through innovation and technology. The loss in manufacturing jobs is a global issue driven by productivity improvements, not outsourcing. Productivity improvements have resulted in increasingly lower labor requirements and outsourcing is only one means of balancing or redistributing global manufacturing among the nations with the most favorable comparative advantage.

Labor:
Current Conditions: According to the National Association of Manufacturers (NAM), external non-production related costs add about 22 percent to U.S. unit labor costs, adding approximately five dollars to the cost of each hour worked (*Cost Burden*, 2006). These non-production costs are costs imposed either directly or indirectly by state and federal governments and include items such as taxes, tort litigation, regulation, rising gas prices, health care, and pensions. These costs have offset a significant portion of the 54 percent increase in manufacturing productivity in the U.S. since 1990. Minimizing these costs has been identified by NAM as the top competitive challenge that manufacturers face (*NAM Cost Study*, 2006).

Challenges: These legacy costs put U.S. manufacturers at a competitive disadvantage against our largest trading partners – Germany, the United Kingdom, Japan, China, France, and Canada. According to the Ford Motor Company, the cost disadvantage (compared to the top nine global competitors) is 5.6 percent for corporate tax rates, 5.5 percent for labor benefits of health care and pension costs, and 3.2 percent in litigation. "The absolute value of the excess cost burden on U.S. manufacturers (nearly five dollars for each hour worked) is almost as large as the total raw cost index for China" (Leonard, 2003).

Critical Capabilities Loss:
Current Conditions: According to the United States War College Quarterly periodical *Parameters,* the U.S. has limited excess capacity available to mobilize during a crisis (Elhefnawy, 2004, p.124-125). However, the Department of Defense's (DOD) latest Defense Industrial Base Capabilities Study concluded the U.S. industrial base is sufficient in producing the critical material to support needs (*Annual Industrial Capabilities Report*, 2006). In March 2005, DOD issued a report concluding DOD procures very few defense articles from foreign suppliers with contracts awarded to foreign suppliers for material totaling $1.5 billion (about 2 percent of DOD contracts for material). United Kingdom and Canadian firms, our strongest allies, were the main beneficiaries of these foreign contracts (*Study on Impact of Foreign Sourcing*, 2004).

Challenges: The principle challenge for most domestic manufactures is global competition. U.S. manufacturing businesses have "right-sized" and employed efficiencies to remain competitive in the international market. Idle production assets have been sold off and corporations consolidated to maximize profitability. "Just-in-time" deliveries have reduced inventory (Elhefnawy, 2004, p.124-125). Multinational corporations, off-shoring jobs, and downsizing indigenous infrastructure fans the flames of 'Buy America' advocacy and supports their concerns that embargo by foreign governments could suddenly deprive the U.S. of a particular key resource.

INNOVATION AND PRODUCTIVITY - The manufacturing industry has undergone a revolution in the past three decades that directly parallels the rise of the information age. Technology and innovation continue to drive productivity growth. According to the Bureau of Labor and Statistics (2005), the manufacturing sector has posted an astonishing five percent yearly average gain in worker productivity over the past 15 years (*Productivity and Costs*, 2005). This section details the current conditions and challenges in the areas of technology, innovation, energy, process improvement and infrastructure that fuel this productivity machine.

Technology and Innovation: The current conditions and challenges of technology and innovation are discussed in Essay #3 –*Innovation and Technology.*

Energy Intensity:
Current Conditions: Energy is fundamental to the manufacturing sector as it converts fuels into thermal, electric, or motive energy to produce goods. A key factor in manufacturing is the energy intensity, defined as the ratio of energy consumption to a measure of the demand for services. Despite improvements in energy intensity over the past few decades, it has been estimated that only 43 percent of all manufacturing energy inputs are applied to process work (*Efficiency and Innovation*, 2006, p.8). Factors that are responsible for the decline in energy intensity include a greater focus on energy efficiency and a reduction in the share of manufacturing activity in the most energy-intensive industries (*Annual Energy Outlook*, 2006, p.8).

Challenges: In the early 21st century, the combination of continued structural changes in the U.S. economy (as the service sector grows) and rising oil and natural gas prices can be expected to encourage further reductions in energy intensity for the economy as a whole. To stay competitive with overseas manufacturing, U.S. manufacturing companies must continue to find innovative ways to improve energy intensity.

Manufacturing Process Improvement:
Current Conditions: Management of the manufacturing enterprise has a considerable effect on productivity of the firm. Most firms use modern production management techniques to improve their manufacturing processes. Two of the key techniques used are the Lean thinking and Six Sigma disciplines. Lean thinking focuses on removing waste from the manufacturing process. The Hyundai plant in Montgomery, Alabama and the Toyota facilities in Nagoya, Japan represent some of the best observed examples of Lean production. Six Sigma focuses on the reduction of variation within the manufacturing process through advanced application of statistical controls. Firms such as Harris and Lockheed Martin in Florida, Honeywell in China, OPV Pharmaceutical in Vietnam, and NGK Spark Plug in Japan use Six Sigma methodologies for quality improvements. Managers have combined these two techniques into a process known as Lean Six Sigma to take advantage of the strengths of each.

Challenges: The high cost of personnel training and staffing, particularly in production engineering departments, deters many smaller firms from implementing manufacturing process improvements. Many of the capital goods such as computer numerically controlled (CNC) machine tools and robots are very expensive. Another challenge is the theft of intellectual property and patent infringement. Some countries allow their firms to reverse engineer systems and components and subsequently copy them, thus avoiding research and development costs.

Manufacturing Infrastructure:
Current conditions: In response to foreign and domestic competition, many companies are moving away from vertical integration. They are switching to a horizontally integrated model that includes long-term supply chain relationships which share risk across the supply chain. As a result, larger companies are not losing infrastructure, but are shifting infrastructure to suppliers who are more nimble and entrepreneurial than the bigger companies they serve (*Manufacturing Infrastructure*, 2006).

Challenges: Market forces have responded and are working to shape success. By improving production techniques and design, and by maintaining key supplier relationships, larger manufacturers are successful in the world market despite significant international threats. Policymakers tend to protect large manufacturers from foreign competition in order to save jobs and prevent perceived losses in infrastructure. World Trade Agreement requirements limit political actions by promoting a free and open global marketplace (*Airbus A350*, 2005).

OUTLOOK AND RECOMMENDATIONS

This section describes our manufacturing team's outlook and recommendations within the manufacturing industry in the areas of globalization, competitiveness, and innovation and productivity.

GLOBALIZATION - The U.S., through its bilateral, multilateral and regional trade strategies, is a participating member of a global economy. The U.S. should continue its participation in organizations such as the WTO and NAFTA, as the benefits substantially outweigh any disadvantages.

Treaties:

Outlook: The U.S. will likely continue to experience positive results from trade agreements such as NAFTA. One example is Mexico's implementation of pharmaceutical rules that honor U.S. patents. Another example is the resolution of market access issues for beef and poultry (*USTR 2005 Trade Policy Report*, 2005).

Recommendations: The U.S bilateral and regional trade strategies should be aimed towards maximizing positive outcomes and minimizing conflicts.

International Organizations:

Outlook: The U.S has multiple incentives to participate in the WTO. Examples include lowering of trade barriers which will benefit U.S. workers and will permit market expansion; stimulating rules that provide a strong legal infrastructure; and preventing "discriminatory tax policies and customs procedures, subsidies, unjustified dumping actions and weak intellectual property protections" (*USTR 2005 Trade Policy Report*, 2005).

Recommendations: The U.S. should continue its WTO participation strategy since the advantages described above substantially outweigh any disadvantages.

Intellectual Property Rights:

Outlook: The U.S trade strategy uses domestic trade law, regional initiatives such as APEC, the WTO and the World Intellectual Property Organization to aggressively address the problem of intellectual property piracy (*U.S. Announces Major New Initiative*, 2004). It is likely that this approach will continue since there is no reason to believe that the problem will resolve itself.

Recommendations: The U.S. should continue to work through various trade organizations to address the problem of intellectual property piracy. In particular, the U.S. should take the lead in the WTO to promote rules that permit action to be taken against countries that are violators, rather than being limited to inquiring about how a country is prosecuting violators.

COMPETITIVENESS - To remain competitive at home and abroad, U.S. manufacturers must emphasize innovation, balance labor compensation, and increase manufacturing efficiencies by directing research and development (R&D) resources towards manufacturing technologies.

Outsourcing/Job Loss:
Outlook: The loss in manufacturing jobs is a long-term, global phenomenon caused by productivity improvements similar to what occurred in the agriculture sector during the 1900s. The law of comparative advantage[1] is driving a global redistribution of manufacturing. The U.S. is shedding low technology manufacturing in favor of high technology. This trend is not one that can be successfully halted without sacrificing our absolute advantage[2] in manufacturing productivity. If productivity becomes stagnant in order to save jobs, then jobs will be lost as other nations' productivity increases.

Recommendations: Successful manufacturing restructuring requires active innovation so the U.S. continues to achieve productivity improvements and maintain its advantage. This approach will ensure the U.S. remains competitive through superior quality while simultaneously controlling costs. Government R&D spending needs to be coordinated among all government R&D activities, including DOD, National Science Foundation, and Department of Energy to optimize use of resources and prevent duplication. This coordinated effort should include partnerships with private R&D and offer targeted tax incentives for innovation in manufacturing processes.

Labor:
Outlook: Manufacturing is faced with the rising cost of health care and pensions for a rapidly aging work force and a large retired population. Unlike their competitors, U.S. companies are responsible for a larger portion of employee health care and pension costs. Nearly 21 percent of U.S. compensation is benefits; well ahead of most of our competitors except South Korea, France, and Germany (Leonard, 2003). NAM found more than 60 percent of U.S. manufacturers were facing a daunting spike in health care costs of at least 13 percent, with smaller manufacturing firms facing health care cost increases of more than 20 percent per year (*Healthcare at the Crossroads*, 2006).

Recommendations: The high expense of human capital in the U.S. has the potential to dull the competitive edge of the manufacturing industry. This has required U.S. manufacturers to look for a balance in labor compensation that will attract the talent they require at a cost that is affordable. More manufacturers will look for ways to shift the escalating human capital costs onto their labor force. The labor force will also see defined benefit plans for retirees replaced with less expensive, portable 401K plans, reflecting the needs of a more mobile workforce. Other health care and pension reform will also be necessary to help stem the rising cost of labor.

Critical Capabilities Loss:
Outlook: According to the OSD/AT&L's Annual Capabilities Report to Congress, U.S., industries are currently capable of producing the products and services that our warfighter and nation depend on without depending on non-indigenous companies. However, due to global competition, U.S. industries will be challenged in the future and the DOD may have to depend more on international industries in the future. Many low technical jobs and services are being

off-shored. Lean manufacturing and "Just-in-time" delivery is reducing indigenous surge capacity. U.S. industries are consolidating and being bought by international conglomerates.

Recommendations: The federal government and DOD have many tools at their disposal to determine whether strategic and important industries are manufactured off-shore and surge capacity is retained. The Defense Industrial Base Capabilities Study used the attribute of "innovation [3] " in recommending where resources should be allocated (*Annual Industrial Capabilities Report*, 2006). Recommend the DOD use more than innovation in determining which indigenous industry is important to protect. Recommend the DOD consider three additional attributes of long learning curves[4], lack of dual-use[5], and large capital investments[6] as key attributes when determining which industries are strategic and important to remain indigenous in our country.

INNOVATION AND PRODUCTIVITY - In order to maintain its competitive edge and to sustain economic growth, the US must continue to invest in technology and innovation breakthroughs to keep productivity high, decrease costs, and continuously improve business processes and infrastructure efficiency.

Technology and Innovation: The outlook and recommendations of technology and innovation are discussed in Essay #3 –*Innovation and Technology.*

Energy Intensity:
Outlook: Energy intensity is projected to decline at an average annual rate of 1.8 percent from 2004 to 2030. Efficiency gains and structural shifts in the economy are expected to dampen the growth in demand for energy. There is an expectation that the shift in output from the industrial sector to the service sector will continue into the future. Future technologies may counteract this shift, such as fuel gasification (a process that converts carbonaceous materials such as coal and petroleum into carbon dioxide and hydrogen) and nanotechnologies, and could have great affect across the manufacturing industry (*Annual Energy Outlook*, 2006, p.42).

Recommendations: Three recommendations are offered to reduce energy intensity. First, although government investment in R&D is crucial, government investment should be supplemented with standards, incentives, information, and education programs. Second, federal agencies, in particular the General Services Administration (GSA) and DOD, should purchase innovative and cost-effective technologies (such as electric vehicles and fuel cells) that reduce energy use and improve the environment. Last, many technology initiatives require coordination across groups and across other Department of Energy (DOE) programs such as renewables, fossil energy, and fundamental energy-linked science programs (including portions of Energy Research and Basic Energy Sciences). DOE should develop clearly articulated technology paths for initiatives that exploit and coordinate R&D resources as appropriate (Holden, 2006, p.3-9).

Manufacturing Process Improvement:
Outlook: Sub-assembly (Tier II) and parts (Tier III) suppliers have the most potential for continuing process improvements as most original equipment manufactures (Tier I) firms have already instituted lean and Six Sigma techniques. Capital spending on equipment such as CNC machine tools, robots, and supporting hardware and software will continue. According to Donald

A. Vincent, the Executive Vice President of the Robotics Industry Association, "We've seen many examples of small, medium, and large companies in just about every industry that have taken advantage of the productivity, quality, and flexibility gains that robots provide in order to compete successfully in the global market" (*Robotics Industry Sets New Records*, 2005, p.1). Tier I manufacturers will increase their support for downstream suppliers as they seek to integrate their supply chains. Lean and agile firms will prosper while those mired in 20th Century industrial processes will fail.

Recommendations: Manufacturers must balance capital investment, workforce improvement, and innovative management to improve both quality and productivity of their manufacturing processes. In some instances, larger firms may have to influence the practices of tier II and III suppliers to ensure that they receive quality parts and assemblies at reasonable prices on a reliable basis. Enlightened tax policy must support investments in production capital such as machine tools, robotics, and computer aided design and process control software to promote growth in productivity. Federal and state support of math, science, and technology education can support the development of human capital that can operate effectively in the competitive global environment.

Manufacturing Infrastructure:

Outlook: America's recent successes in business are in high tech industries such as information technology, which provides a comparative advantage versus low tech products such as textiles which have largely been outsourced overseas. Protection of intellectual property rights (IPR), growing patent violations, and copyright infringements are concerns; violations cost innovative companies' market-share and profit.

Recommendations: The U.S. must focus on high-end manufacturing to be competitive in the global marketplace**.** The areas the U.S. needs to pursue are sectors that require engineering prowess, sophisticated production techniques, and intellectual capital. The U.S. should not expend diplomatic or political capital attempting to protect labor intensive, low tech production where the U.S. will never again be competitive (Averett, 2004). However, the Government must assist manufacturers by enforcing international legal regulations and pressuring countries committing IPR violations through the use of economic sanctions.

CONCLUSION

Manufacturing has long been recognized as the engine of U.S. economic growth. Productivity growth is the major contributor to our prosperity: our tangible wealth and standard of living. But there is increasing concern that the growth engine is losing steam, primarily to globalization and foreign competition, lack of skilled workers, and high energy costs. The U.S. manufacturing industry must continue to aggressively leverage improvements in productivity, training, innovation and technology, and partnerships abroad, to maintain productivity growth and remain globally competitive. We are seeing a restructuring of manufacturing resources to products requiring high skills and an increasing use of innovation and technology to improve productivity. The U.S. must continue to seek partnerships with close allies, and encourage innovation, development of new technologies, and education to drive productivity growth and thus maintain our strategically important manufacturing base.

ESSAYS ON MAJOR ISSUES

Essay #1: SKILLED LABOR SHORTAGE

OVERVIEW

Despite recent low unemployment levels, U.S. manufacturing is experiencing a deficit in qualified workers to fill job vacancies. In a study conducted by Deloitte Consulting LLP and the National Association of Manufacturers, the results indicate that at least four of five manufacturers are experiencing moderate to severe shortages. Eighty-three percent of 800 companies responding to the study report the shortages influence their ability to meet production levels and maintain customer service and satisfaction (*Skills Gap Report*, 2005, p.1). Many automatically assume the skills deficit is due to the loss of over two million manufacturing jobs during the recent recession. The job loss, however, only masks the real problem in manufacturers' ability to find technically competent and highly skilled employees to fill the vacancies for engineers, scientists, machinists, technicians and operators (*Skills Gap Report*, 2005, p.1).

ANALYSIS OF TRENDS

While the education system's inability to keep pace with new technologies contributes to the skilled labor shortage, other reasons such as changes in workforce demographics, inadequate basic skills, lack of engineers and scientists, and lack of interest in the manufacturing industry contribute to the problem as well.

With the first members of the Baby Boomer generation turning 62 in 2008, many veteran workers will be retirement-eligible and could retire at a time when the manufacturing industry is suffering a skilled labor shortage. In the automotive industry alone, up to 40 percent of managers will be eligible to retire within the next five years (*NSF Figure 1-5*, 2006). The concern is these retirees could take their skills with them and leave a void in skilled replacements. It is disconcerting that many young people are not prepared to meet the challenge or are not interested in the industry at all. With the over 65 population growing by 14 million by 2010 and the numbers of 18-24 year olds projected to grow by only four million, the problem is only going to get worse (*The Facts about Modern Manufacturing*, 2006, p.48).

In addition to universities awarding fewer students with engineering and science degrees, 30 percent of students do not complete high school (*It's 2008*, 2004, p.3). More alarming is a 2003 National Science Foundation study that shows less than 20 percent of high school seniors are at or above the proficiency levels for their grades in math and science (Davenport, 2006). While minimal computer training is becoming a more prevalent requirement for many jobs, a large number of students leave high school without basic computer training, math skills, and science skills. In addition to the absence of basic skills, many college and high school graduates lack interest in the manufacturing industry altogether due to the stereotypical "assembly line" image of the industry.

GOVERNMENT'S ROLE IN SUPPORTING SKILLED LABOR

In order to remain competitive in the global market, the lack of skilled labor must be addressed from the top. As reported by the Department of Commerce's Assistant Secretary for Manufacturing and Services to the Senate, the federal government has taken several steps during FY06 to ensure America sustains its economic prosperity through various initiatives. First, $1.5 billion was allocated for the High School Initiative to ensure more students graduate with the

skills required to compete in the competitive workforce and succeed in college. Secondly, $250 million was provided for community-based grants and the Jobs for the 21st Century Initiative aimed at strengthening training provided by technical and community colleges. Lastly, $60 million was invested in the High Growth Job Training Initiative for Advanced Manufacturing developed to establish partnerships between "employers, training providers, and the workforce investment system" (Frink, 2005, p.9-10). The significance of the manufacturing industry to the US economy requires continued support and attention of the administration.

RECOMMENDATIONS

Combined national, state and local governments must work together coupled with manufacturers, communities and individuals are required to address the problem. Making this issue a priority along with increased partnerships (manufacturers with governments, colleges, technical schools and communities) and marketing at all levels (displays, booths, community job fairs, and factory tours) will raise awareness and increase participation of stakeholders locally and nationally.

Although the American manufacturing industry remains vibrant, its ability to continue to be a strong competitor in the global economy will be predicated on the ability of the U.S. to maintain a highly skilled workforce. The inability to maintain a high-performing workforce could shift the labor shortage into a labor crisis for the industry. *(By Sarah Braswell, DAF)*

Essay #2: SURGE AND MOBILIZATION

OVERVIEW

This essay discusses the current operating environment in which American manufacturers and DOD organic depots operate; techniques used by American manufacturers to react to DOD surge and mobilizations requirements; tools available to DOD to ensure critical item priority support from the industrial base; and finally policy considerations for the DOD that may help ensure American manufacturers continue to be well positioned to support 21st century warfare.

ANALYSIS OF TRENDS

Even though DOD labeled the industrial base "sufficient" in their 2006 report to Congress, DOD also expressed concerns about industrial capacity supporting critical items in certain segments of the market (*Annual Industrial Capabilities Report*, 2006, p.2). A September 2005 Defense Contract Management Agency (DCMA) study (cited in the 2006 DOD Report to Congress) analyzed each industry's prime and key sub-contractor production capabilities, current and surge production rates, factors limiting production, and lead times (*Annual Industrial Capabilities Report*, 2006, p.2). The DCMA study made several conclusions about different aspects of the manufacturing industry. The DCMA found the Munitions Industry is healthy despite being directly dependent on DOD for funding and the Unmanned Aerial Vehicles (UAV) Industry is consolidating but competition still exists across the four domestic producers. Additionally, the DCMA study found the Chemical Defense Industry could support 100 percent surge with relatively little effort and, with help from DCMA input to the Priorities and Allocations of Industrial Resources Board (PAIR), the domestic industrial base was able to meet DOD requirements for ceramic body armor plates within their capacity.

During our industry visits, company representatives described strategies to deal with surge requirements. These strategies ranged from generally reactive labor-based strategies on the

unsophisticated end, to sophisticated proactive approaches to improve requirement forecasting accuracy. Generally, companies developed aggressive and proactive systems to forecast demand and optimize the supply chain, therefore positioning themselves to respond to surge requirements.

GOVERNMENT'S ROLE IN SUPPORTING SURGE AND MOBILIZATION

Despite DOD's philosophy that market forces should guide the development and sustainment of the industrial base and the various strategies employed by commercial industry to respond to surge requirements, there are times when markets and companies fail to provide the surge capability required by the DOD. Outlined below is a key legislative tool available to DOD to assist the market in meeting its surge requirements.

DOD's primary legislative tool to ensure availability of essential industrial resources and critical technology required for national defense is the Defense Production Act (DPA) (*DPA*, 2006). DOD works with the Department of Commerce (DOC) to resolve conflicts for industrial resources between commercial and defense contracts, as well as between services, when conflicts arise due to limited industrial resources. Title III of the DPA is "specifically designed to establish, expand, maintain, or modernize industrial capabilities required for national defense" when no capacity exists or when domestic capacity will not meet DOD requirements (*Annual Industrial Capabilities Report*, 2006, p.37). Title III allows DOD to provide financial incentives to commercial industry to offset the risk of establishing the capacity needed by DOD. A key example of this type of incentive is found in Beryllium production. Because imports seldom can meet the purity levels required for defense applications, DOD is attempting to incentivize a new primary production facility using a DOD–private cost share program (*Annual Industrial Capabilities Report*, 2006, p.37).

RECOMMENDATIONS

In addition to legislative tools such as the DPA, DOD should consider creating both public and private sector incentives to optimize the DOD supply chain for critical items. Incentives, aimed at both the public and private sectors of the supply chain, should be focused toward creating better forecasting techniques; increased public-private partnerships; reduced acquisition lead times; and increased information sharing with the increasingly concentrated defense industrial base.

Though the DOD labels the Defense Industrial Base "sufficient" and "well-positioned to supply the most critical technologies enabling 21st century warfare", DOD realizes that problems supporting DOD surge requirements do exist and will continue to exist. In order to ensure American manufacturers continue to be well positioned to support 21st century warfare, DOD must continue to employ currently available tools such as the Defense Production Act both to minimize foreign supplier dependency and to have raw material immediately available to support production is support of national emergencies. In addition to existing tools, DOD leaders should consider providing real incentives to optimize the supply chain for critical items across both the private and public sector portions of their supply chains. *(By Duane Gamble, COL, USA)*

Essay #3: INNOVATION AND TECHNOLOGY

OVERVIEW

Innovation and technology are the life blood of the manufacturing industry; without them companies cannot maintain their steady growth in productivity requisite for staying competitive and survival. Innovation and technology have "….generated the productivity that has accounted for half of the GDP growth over the past 50 years, and has been the seedbed for generating new ideas directly leading to the continual increase of quality of life in America" (Engler, 2006, p.84).

ANALYSIS OF TRENDS

Today the U.S. is the global leader in manufacturing innovation and technology. Continued advancements in both computing power and information technology have allowed the U.S. to maintain steady productivity growth. However, there are several growing industrial nations, such as China and India, which could challenge that reign. Through the use of vast resources like excess human labor and low wages, these nations continue to lure businesses overseas.

GOVERNMENT'S ROLE IN SUPPORTING MANUFACTURING

The applications of the art and science of modern manufacturing innovation and technology are not exclusive to the U.S. economic instrument of power inherent in the private sector. The U.S. government plays a pivotal role in ensuring that the system that spawns American innovation is robust, provides the proper incentives for innovation, and ensures a consistent pool of educated labor in order to continue to produce the productivity growth of the past three decades.

RECOMMENDATIONS

To keep the U.S. competitive edge in innovation, there are several steps that must be taken. In the area of education, there should be an increased emphasis on math and science from elementary school through high school. Students should be encouraged to work together and pool their creativity/imagination to stimulate innovation. The private sector must play an active role by reestablishing high school internship programs in the technology economy. At the college level, the U.S. government must fund university research and provide incentives for innovative partnerships between private industry and higher education centers.

R&D must become a worthwhile investment. To accomplish this, programs to encourage investments that enhance productivity through R&D, education, and worker training must be created. This will require increased federal spending on basic R&D and improved tax incentives. Accordingly, the intellectual property infrastructure needs to be bolstered to protect R&D investment (Popkin & Kobe, 2006, p.vi).

To ensure that DOD leverages the private sector's investment in manufacturing technology, policymakers should apply "Digital Thread" technologies to all DOD system acquisition programs which link all aspects of the system together from Computer Aided Design (CAD) to Computer Aided Manufacturing (CAM) to operations support and logistics. This will have the effect of enhancing traceability and transparency throughout the system and will enable designs that are more robust, more cost effective production, and system-wide integrated product support initiatives.

Several such initiatives that should be considered include Battlefield Production, and prototype programs like the Mobile Parts Hospital which could minimize logistics footprints and provide a quick reaction production capability. DOD should commit to employing the latest manufacturing technology such as three dimensional printing (3DP), mobile CNCs, and robotics. Better teamwork would be the outcome of mandating the use of virtual collaboration tools like collaborative white boarding and data sharing. Enterprise Resource Planning (ERP) should be developed and deployed to provide an end-to-end systems engineering ERP approach including planning, organizing, tracking and controlling the environment at the management level.

"Technology and knowledge are the drivers in manufacturing, because technology creates wealth and fuels growth" (Moody & Morley, 1999). The art and science of today's manufacturing technology and innovation is creating the wealth and fueling the growth of the US economy through seemingly endless advances in innovation and productivity. To stay ahead of competing nations and remain as the global leader in manufacturing innovation and technology, American companies must continue to invest in R&D, and American government must ensure that this investment is incentivized, protected, and populated with an educated workforce. Finally, DOD must capitalize on this private sector investment by adopting modern manufacturing technology and processes to enhance its efficiency and warfighter effectiveness. *(By Lee Rosen, LTC, USAF and Timothy Burns, LTC, USA)*

Essay #4: THE MANUFACTURING TRANSFORMATION

OVERVIEW

The U.S. manufacturing industry has experienced increased competition from foreign and domestic competitors and has lost significant market share in low technology manufacturing. Most disconcerting to Congress, media, and the public is the perception that U.S. manufacturing capacity and jobs have shifted overseas. This issue is particularly worthy of study when it concerns commercial industrial capability that may be required to support national defense (Bush, 2006). Many industries have simply moved away from vertical integration internal to their company and are switching to a model that includes long-term relationships with specific suppliers. Larger companies are not losing infrastructure, rather their location has shifted to suppliers who are more agile (*Manufacturing Infrastructure*, 2006).

ANALYSIS OF TRENDS

U.S. manufacturing jobs are declining in gross numbers due to a decrease in demand for domestically manufactured products and increased efficiency in manufacturing productivity. As for loss of demand, the Bureau of Labor Statistics estimates that 2.53 million jobs were lost due to domestic consumption reductions (Bureau of Labor Statistics, 2006). As for loss of jobs due to increased productivity, 2.74 million jobs were lost (Bailey, 2004). From a global perspective, 22 million manufacturing jobs were lost despite a rise in productivity of over 30 percent. Primary nations affected included Japan, Brazil, and even China losing 16, 20 and 15 percent of their manufacturing jobs, respectively (Zuckerman, 2004). In response to these job losses, the law of comparative advantage is forcing global manufacturing to redistribute production. In the case of the U.S., low-technology production is being shed, and high-technology production is being retained.

GOVERNMENT'S ROLE IN SUPPORTING MANUFACTURING

Innovation in manufacturing technologies to improve productivity is critical to the future of the U.S. manufacturing industry. To ensure the U.S. remains competitive, the U.S. government is focusing research and development (R&D) resources and policies to develop technologies that require fewer workers, be ever more responsive to customer needs, and produce the highest quality products. A 2005 Georgia manufacturing survey of 650 companies determined, "manufacturers that rely on innovation for their competitive edge reported returns on sales 50 [percent] higher than companies that compete by providing low cost products" (*Manufacturing Survey*, 2006). President Bush's *American Competitiveness Initiative* is providing 136 billion dollars over 10 years for R&D which is a good start, but must be monitored closely to ensure the spending levels are producing the desired effects (Hitt, 2006).

RECOMMENDATIONS

Focus on high-end manufacturing and legal enforcement. America's recent successes in business are high tech. U.S. government needs to focus their R&D resources and policies toward industries that require engineering prowess, sophisticated production techniques, and intellectual capital. Protection of intellectual property rights and the growing amounts of patent violations, and copyright infringements are of concern and need to be diplomatically resolved.

Tax policy: Innovation in production requires high levels of capital investment, for which the federal tax code should be revised to stimulate more private investment in capital improvement. *(By Robert Bellitto, CAPT, USN, and John Westerbeke, CAPT, USN)*

Essay #5 – ENVIRONMENTAL BALANCE

OVERVIEW

Efforts to establish enforceable international environmental regulations for manufacturing date to the 1950s.[7] Initial efforts were focused on limiting pollution, with regulations augmented by educational and disclosure measures, and backed by fines and occasional criminal prosecution. Enforcement in developing countries has been sporadic, though significant improvements were achieved world wide. Challenges continued to persist however, and by the early 1990s many countries viewed conventional techniques as expensive to enforce and often harmful to specific sectors of the economy. In 1990, The United States introduced a new Clean Air Act, pioneering the use of market based instruments to better achieve desired environmental outcomes. These regulations were unique in that they allowed corporations to trade pollution credits as property rights. Variations rely on selective use of credit subsidies, tax forgiveness, or implementation of laws that empower citizens and organizations to pursue litigation, discouraging poor corporate behavior. These new regulations achieved remarkable results.

ANALYSIS OF TRENDS

Many challenges remain especially in poorer countries with weak regulatory institutions as they find it difficult to oversee and enforce effective pollution abatement programs. Businesses often view compliance as important, but diametrically opposed to corporate profitability. In many countries, regulators continue to impose across the board abatement standards that require all to achieve the same level of compliance even though abatement cost varies widely from one factory/industry to another. This results in far higher costs overall, and

greater economic damage, than if corporations have flexibility to pursue target reductions first where abatement costs are lowest.

More recently, world environment and resources are coming under pressure as never before, with continued population growth in undeveloped countries, and rapid economic growth in China, India and other Asian countries as they seek to improved living conditions for their citizens. World population is projected to increase from 6.5 billion at present to more than 7.3 billion by 2016, with the population of India alone anticipated to be larger than that of all developed nations combined.[8] Population growth combined with rapid economic development will place great pressure on both resource supplies and environmental quality over the next 10 years.

GOVERNMENT'S ROLE IN SUPPORTING MANUFACTURING

There is no single solution that best supports effective manufacturing and economic development while protecting environmental conditions. Governments can best support manufacturing industries through the use of regulatory instruments that best match their unique situations. Developed countries with strong institutional regulatory capability should assist developing nations with technical expertise and strong support for standardized corporate compliance reporting. All countries should make use of market based instruments to achieve desired environmental outcomes when possible, and most important of all, countries should recognize the potential cost of environmental mismanagement and ensure effective regulation of critical environmental factors.

RECOMMENDATIONS

Market based environmental incentives work. They should be continued and expanded as necessary to address new concerns such as carbon dioxide emissions/global warming. Today, the U.S. maintains sulfur dioxide at 1990 levels, 40 percent below levels of thirty years ago due to the use of these innovative techniques (*The Plain English Guide…*, 2006, p.1). We also must continue to lend technical compliance assistance to officials in developing countries. Finally, the United States needs to facilitate standardized compliance reporting that addresses world pollution, environmental, and work conditions. Corporate Responsibility reporting is a valuable tool for managing risk associated with environmental, social, and economic disruption, and projecting accountability in countries with weak enforcement capabilities. Environmental policies will continue to play a key role by either facilitating competitive advantage, or by hobbling enterprises with the negative externalities brought on by poor environmental management and pollution. *(By Michael Beaulieu, CDR, USN)*

Essay #6 – INTERNATIONAL TRAVEL IMPRESSIONS

OVERVIEW

This essay discusses the impressions and insights acquired during the international travel portion of the Manufacturing Industry Study program. The thoughts included in this essay were compiled from input from seminar members.

Our international travel took us to Beijing and Chengdu, China; Ho Chi Min City and the Mekong Delta region of Vietnam; as well as Nagoya, Japan. Companies visited during our travel included State Owned Enterprises (SOEs); foreign direct investment (FDI) companies operating in these countries; and domestically owned and operated companies.

In each country and in each company visited, it was clear that the global economy is real and present. In broad terms, Japan appeared to be a fully developed country with infrastructure and labor costs comparable to the United States; China appeared to be a developing nation with rapidly growing infrastructure and low, but rising labor costs; and Vietnam appeared to be an emerging industrial nation with very limited infrastructure and low labor costs. In terms of developmental progress, Japan seemed on par with the United States; China appeared to be ten years behind Japan in their development; and Vietnam appeared to be ten to fifteen years behind China.

ANALYSIS OF TRENDS

Transition to Market Economies: Market-style economies are growing at a very fast pace in both China and Vietnam despite their respective Communist Governments. Both China and Vietnam have enjoyed strong economic growth for the past several years.

Chinese GDP growth (in real terms) has hovered around the 9 percent mark (plus or minus 2 points) for the past ten years (China Statistical Yearbook, 2005); while Vietnam's GDP growth (in real terms) was approximately 5 percent from 1999-2001, approximately 6 percent in 2002, and over 7 percent from 2003 to present (CIA World Fact book, 2005). Arguably, growth rates could have been higher in China and Vietnam if their economies were not hampered by Communist Governments, SOEs, and significant efforts toward central control and regulation.

Japanese GDP growth (in real terms) has averaged approximately 1.5 percent from 2001 through 2005 as Japan struggled to recover from their recession of the early 1990s and the impact of the Asian financial crisis of 1997-1998 (Joint Economic Committee Report, 2005). Japan's insular society and resistance to non-Japanese workers appeared to be an obstacle toward some companies' growth.

Our impression from International travel was that China was largely unaffected by the Asian financial crisis of 1997-1998; that Vietnam was slightly affected; and that Japan was moderately affected primarily due to their large exportation of goods to other Asian countries hit harder by the crisis.

Loss of Manufacturing to Asian Countries: Before international travel, virtually every seminar member knew that significant portions of manufacturing from developed nations had moved to Asia to take advantage of low labor costs but few members, if any, had an appreciation for the challenges and constraints these international companies faced. In short, challenges faced by companies in Asian markets, although different in scope and complexity, were as decisive to the success of companies there as challenges faced by American companies here in the states.

Factory workers in China and Vietnam appeared to earn between $60 and $100 per month, while Japanese labor rates were comparable to the United States. While factory workers were plentiful, skilled labor and skilled management were extremely rare in both China and Vietnam. Every foreign owned company visited in China was run by a foreign Operating Officer, despite heavy investment over several years in attempts to build Chinese-National management teams. Each foreign-owned company visited in China hoped to (one day) hand-off company management to a Chinese Operating Officer, but every company visited was at least one year away from attaining their goal.

Foreign companies with experience in Asia characterize Vietnamese workers as more productive than China, but less productive than workers in developed nations such as Japan and the United States. While their unskilled labor force was more productive, foreign-owned

companies in Vietnam faced the same challenge as those in China in terms of educating and building Vietnamese management teams to operate their companies. While several foreign-owned companies in China had weaned their companies down to only a foreign Operating Officer, several management layers in foreign-owned companies in Vietnam were almost completely manned by foreign managers.

Vietnam and China appeared to both suffer from a lack of educated people with corporate management experience. Specifically, foreign managers described Chinese and Vietnamese managers as not possessing experience in team-based problem solving and innovation. Intelligence or formal education for corporate managers seems not to be an issue in China or Vietnam – both countries place a high value on education. English is taught in schools and most educated Chinese and Vietnamese had a good grasp of the language.

While significant portions of developed nations' manufacturing has moved to China and Vietnam, the lack of protection for intellectual property rights has limited the level of manufacturing technology exported to these countries. Most company ventures in China and Vietnam represent only a small portion of their overall supply chain; portions that are low-risk to pirating and portions that can easily leverage the low costs of relatively unskilled labor. Additionally, many companies in China have shifted their focus from merely exploiting low cost labor to manufacturing products in China for the growing Chinese market. Even ventures to exploit the domestic Chinese market tend to be less-than-leading-edge products and tend to employ less-than-leading-edge manufacturing techniques due to threats of piracy.

Lastly, a major obstacle to large-scale exodus of manufacturing to countries such as China and Vietnam is the relative lack of infrastructure. Japan's infrastructure is that of a fully developed nation and is on par with the United States. China's infrastructure is that of a developing nation and is world-class in limited areas since China was able to develop infrastructure without the burden of legacy systems. For example, China entered the information age by purchasing the best Enterprise Resource Planning tools and by laying a network of fiber-optic cable, thereby skipping earlier versions of infrastructure that long-developed nations are only now replacing. Vietnam's infrastructure is the worst of all countries visited and is estimated to be fifteen years behind China's infrastructure.

GOVERNMENT'S ROLE IN INTERNATIONAL MARKETS

Two areas warranting United States Government attention emerged from our international travel: protection of Intellectual Property Rights and support to foreign militaries through military owned SOEs.

The lack of protection of intellectual property rights (IPR) clearly has retarded economic growth in China and, to a lesser degree, Vietnam. Companies investing in China simply will not manufacture highly technical products or employ leading edge technologies in China for fear of piracy. American companies in China, producing only components for American companies in the United States are among those impacted by China's failure to enforce IPR. Vietnam seems to have learned from China's experience and has targeted and attracted slightly higher technologies than China, but these technologies are still well short of leading-edge.

Several Vietnamese SOEs are operated by the Vietnamese Army and produce commercial textile products for both domestic and export sales. These companies support the Vietnamese Army with similar products, though military "sales" constitute a small portion of total sales. These companies constitute a warm, organic military capability from which large scale mobilization of the Vietnamese Army can be supported. In the event of mobilization,

company capacity (purchased during peace with textile sales to foreign markets including the United States) could rapidly be turned full-scale toward manufacture of Military products. According to a State Department representative, China maintains a warm military industrial base in the same manner.

RECOMMENDATIONS

IPR protection must remain high on the United States diplomatic agenda for China and Vietnam, but export controls for manufacturing technologies should be re-examined with an eye toward granting exceptions for American overseas manufacturing facilities that are part of closed supply chains feeding American manufacturers.

The United States Department of State should determine if direct financial support to foreign militaries (through purchase of retail goods) is compatible with United States Foreign Policy and National Security Objectives. If financial support of this type is contrary to U.S. Foreign Policy and National Security Objectives, then diplomatic and/or economic actions should be considered and aimed at preventing such support. *(By Duane Gamble, COL USA***)**

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ENDNOTES

[1] The law of comparative advantage states "one country has a comparative advantage over another in the production of a particular good relative to other goods if it produces that good less inefficiently as compared with the other country" (Baumol & Binder, 2006, p. 715).

[2] Absolute advantage is the ability to "produce [a] good using smaller quantities of resources than … the other country" (Baumol & Binder, 2006, p. 715).

[3] The Defense Industrial Base Capabilities Study series assessed the sufficiency of the industrial base for priority critical technologies in each functional capability area and extra attention was focused on those warfighting capabilities where the US should lead any potential adversary. How far the US should lead their adversaries is defined by the following definition: *Neutral, Equal, Be Ahead, Be Way Ahead,* which established the degree of innovation desired in the industrial base. A warfighting capability that is ubiquitous, matured, and available to all countries, typically had a *Neutral* attribute. Technologies linked to *Neutral* warfighting capabilities required minimal innovation and could be sourced from the global marketplace. In contrast, a warfighting capability that brings key US advantages has a '*Be Way Ahead'* attribute. DoD focused on the warfighting capabilities where DoD needed to achieve and maintain the greatest lead; then DoD identified the priority critical technologies that enable these capabilities and provide assessments of the associated industrial base. When an industrial base deficiency, whether immediate or projected, was identified, DoD examined it in more depth and recommended remedies. Technologies associated with *Be Way Ahead* warfighting capabilities must lead by multiple technology generations, must be highly innovative, and often require effective competition among suppliers to be sustained (*Annual Industrial Capabilities Report to Congress* (Rep.). (2006). Washington DC: Office of Under Secretary of Defense for Acquisition, Technology & Logistics, Industrial Policy).

[4] Long-learning curves: This attribute describes industries which occur where art meets science, or where the production of a component cannot be produced without an abundant amount of human knowledge is leveraged and interfaced during multiple phases of the production. These industries maintain staffs that slowly become sufficient in their craft over their lifetime. Where experts pass down their knowledge and techniques to journeymen over decades and where journeymen do not become experts without large amounts of hands-on practice. No amount of manufacturing technology investment is successful in automating the industry where "art meets science." Two possible industries which fit this definition are the development and mixing of large solid rocket motor or munitions explosive material. These materials have complex recipes, with complex techniques when mixing large batches, curing, and pouring the material safely and still meeting the reliability and performance the warfighter requires.

[5] Dual-use: This attribute describes industries the DoD alone depends on, and there is no other commercial customer equivalent in the market place. The munitions fuse industry is a good example of this industry. The mining industry uses explosives and has simple fuses to initiate its explosives; however, the fuse the warfighter requires cannot be considered in the same industry. In many U.S. DoD munitions programs, the munitions fuse is usually on the list of medium to high risk issues for the program to manage. The fuse has difficult performance specifications of limited weight and size, and it has to perform under extreme environments of high accelerations

[6] Large Capital Investment: This attribute describes industries that require large capital investment. Industries that fit this category are large ship and aircraft manufacturing, oil refining, and steel production. These industries can be re-built with large amounts of funding, yet does the

warfighter have the luxury of time to wait its construction and growing pains until at full capacity is ready to support the surge required.

[7] Allchin, Douglas, The Poisoning of Minamata, retrieved from the University of Minnesota, SHiPs Teachers Network, 05Apr06. This event evolved around mercury poisoning disaster in 1956, when Chisso Corporation, a manufacturer of plastics chemicals, caused the death of 20 persons and made thousands of citizens chronically ill in the fishing town of Minamata. Source: http://www1.umn.edu/ships/ethics/minamata.htm

[8] Projections based on United Nations population Division, Department of Economic and Social Affairs,