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**ADVANCED MANUFACTURING:
A POSSIBLE ASYMMETRIC ADVANTAGE TO
ENSURE SECURITY, PROSPERITY, AND VALUES**

ADVANCED MANUFACTURING INDUSTRY STUDY

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Seminar #3

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Seminar #3 – Advanced Manufacturing Industry Study

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Executive Summary

Despite growing tension over threats to the current world order, the U.S. and like-minded partners maintain the power, tools, and competitive advantage to continue leading the pursuit of economic prosperity, preservation of peace, and defense of sovereignty for all nations. Advanced manufacturing is one such tool that, if developed and employed appropriately, offers the opportunity to further the concept of global prosperity and thwart revisionist ambitions. Analyzing advanced manufacturing is complicated because it is not an industry but a system of technological processes and products that are rapidly evolving. Reinforcing domestic manufacturing by progressing and integrating advanced technologies can help restore U.S. manufacturing capacity, maintain its leadership on the world stage, and usher in the next era of economic prosperity.

Advanced manufacturing can enhance output, increase the added value of products, improve the quality of products, and improve the resilience and flexibility of the U.S. economy. It shortens research and development timelines through advanced prototyping, reduced material consumption, and lower required inventory within the industry. Advanced manufacturing offers one solution, across diverse sectors and industries, to the challenges of time-sensitive critical demand and the shortfalls of just-in-time production. To further global prosperity and thwart revisionist ambitions, the U.S. should focus policy implementation on developing a manufacturing workforce, establishing regulatory standards, ensuring access to critical goods, and resolving intellectual property challenges to usher in the increased adoption of advanced manufacturing to provide an asymmetric economic advantage.

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As the chapter of the first quarter of the 21st century closes, the question of what the world looks like hangs in the balance. The United States and the People’s Republic of China (PRC) appear destined for long-term competition if not outright conflict.¹ The nexus of the industrial and information revolutions at this pivotal point in history may hold the key to the future. The U.S. has lost ground over the last 40 years to China in manufacturing output.² The PRC’s access to its large population, government-coordinated industrial policies, and abundant resources through the Chinese Communist Party’s (CCP) Belt and Road Initiative (BRI) make it a behemoth of traditional mass manufacturing. The U.S. might overcome China’s advantages in manufacturing with the technological benefits of advanced manufacturing.³ Nations that leverage technology to catapult their economies to new heights can gain influence on the international stage to affect the global order. Today, the U.S. is the world’s largest economy and enjoys the benefits of such, but that is under threat. China’s rapid economic and military rise challenges American leadership. Instead of relying solely on military strength, the U.S., its partners, and Allies can challenge China’s meteoric rise with new technology. A coordinated effort to transition from an outdated manufacturing culture to one of advanced technology and innovation can challenge the global economic détente. A strong economy enables the defense of the homeland, powerful diplomatic influence, and the security of a nation’s health and welfare. *The U.S. should promote advanced manufacturing technology for an asymmetric advantage in pursuit of America’s overarching aims: to maintain the U.S. position as the global leader, secure a prosperous economy, and remain the partner of choice for like-minded nations.*

¹ Graham Allison, “The Thucydides Trap: Are the U.S. and China Headed for War?,” *The Atlantic*, September 24, 2015, <https://www.theatlantic.com/international/archive/2015/09/united-states-china-war-thucydides-trap/406756/>.

² Darrell M West and Christian Lansang, “Global Manufacturing Scorecard: How the US Compares to 18 Other Nations,” Brookings (Brookings, July 10, 2018), <https://www.brookings.edu/research/global-manufacturing-scorecard-how-the-us-compares-to-18-other-nations/>.

³ Advanced Manufacturing (AM): AM is defined as “the innovation of improved methods for manufacturing existing products, and the production of new products enabled by advanced technologies.”

Assessment of the Strategic Environment

A clear understanding of the strategic environment is required to identify challenges and opportunities and develop associated solutions to address them. This strategic environment analysis is bounded by a geopolitical assessment, a U.S. domestic assessment, supply chain analysis, and the current interested stakeholders in U.S. advanced manufacturing. While other areas provide additional context, these four areas provide the most complete picture of the external and internal environment advanced manufacturing must work within today.

The global security environment is shifting. The U.S.-led rules-based international order and an emerging multipolar world are converging in long-term, sustained competition for primacy. The PRC and Russia seek to build a coalition of like-minded states to challenge U.S. leadership and redefine national sovereignty and self-determination principles. The current Russian-Ukraine War, mounting concerns about potential conflict in the Taiwan Straits, enduring violent extremist organizations, and new contested domains, like space and cyber, all illustrate the fragility of the current international order and long-standing peace. Post-pandemic supply chain interruptions and rising inflation also threaten global stability.⁴ Climate change, mass migration, and regional conflicts may further change international standards of behavior in the coming decades.⁵ The potential threat to U.S. dominance and the rise of strategic competition challenge U.S. economic prosperity and national security.⁶ The U.S. must simultaneously leverage its national will and instruments of power to maintain and improve its global position.

⁴“Global Economy: Outlook Worsens as Global Recession Looms – IMF,” UN News, July 26, 2022, <https://news.un.org/en/story/2022/07/1123342>.

⁵“Biden-Harris Administration's National Security Strategy,” accessed March 23, 2023, <https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf>.

⁶“Biden-Harris Administration's National Security Strategy,” accessed March 23, 2023, <https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf>.

Although the geopolitical environment is rapidly changing, the U.S. and its allies and partners maintain substantial global economic, diplomatic, and military advantages. One example is the North Atlantic Treaty Organization's response and expansion due to Russian aggression. Current international efforts to support Ukraine demonstrate the value and resolve of nations to use diplomatic efforts and military aid to protect internationally recognized democratic principles while limiting conflict escalation. Another example is the Quadrilateral (Quad) Security Dialogue between India, Japan, Australia, and the U.S. The Quad provides a peaceful and inclusive alternative to the PRC's unilateral expansion in the Indo-Pacific region. Both examples demonstrate the benefit of solid alliances built upon trust and mutual benefit. The U.S., to remain the partner of choice for other nations, must continue working peacefully to demonstrate the collective benefit of a U.S.-led international order over a Sino-centric one led by the PRC that benefits China above all else.

The PRC's long-game approach to building its economy is not the only factor disrupting the status quo. The U.S. enjoys strong international influence. However, domestically, it is challenged by economic uncertainty and intense political discourse that competitors may easily exploit. The U.S. Gross Domestic Product (GDP) is projected to grow at an average rate of only 1.4% over the next decade, which could exasperate the political divide as Congress grapples with raising taxes or reducing spending.⁷ Inflation is surging interest payments on the U.S. national debt, affecting expenditures on national security and military modernization efforts. Additionally, increased political polarization fuels social unrest and presents adversaries with opportunities to drive wedges into American society. Despite the increased friction, there is still

⁷ Congressional Budget Office projections detail annual deficits of \$2 trillion over the next decade, approaching nearly \$3 trillion by 2033. Per "The Budget and Economic Outlook: 2023 to 2033 | Congressional Budget Office," February 15, 2023, <https://www.cbo.gov/publication/58848>.

one unifying topic for an acrimonious legislative branch: providing worthwhile jobs with decent pay for their constituents is good for growing America's economy.

The U.S. economy realized a shift in the manufacturing workforce from a high of 32% in 1950 to 9% in 2015. Correspondingly, manufacturing as a percentage of GDP shifted from 28% in 1953 to 8.5% in 2020.⁸ The offshoring of manufacturing is coupled with this decline in the manufacturing workforce. Meanwhile, the National Strategy for Advanced Manufacturing acknowledges a shortfall in filling two million manufacturing jobs by 2030.⁹ This could negatively impact the U.S. economy in an estimated \$1 trillion loss in GDP.¹⁰ The U.S. government must address this disconnect in employment opportunities and the workforce available to employ. The skills required by tomorrow's workforce are evolving at the same breakneck pace as industry itself; however, employment policies and practices are falling behind. Methods for educating, training, upskilling, promoting, and connecting employers and workers are critical to a prosperous economy and imperative to advance U.S. manufacturing.

Traditional modes of production capacity lost over decades of offshoring will likely never return to the United States. The specialization and strides made abroad in traditional manufacturing sectors have rendered the investment in them domestically inefficient and unprofitable. Additionally, many conventional manufacturing activities involve a low rate of innovation in a mature industry operating on slim margins. The resource-intensive investment needed to compete in the traditional manufacturing of many goods is not cost-effective or

⁸ Chien , YiLi, and Paul Morris. 2017. "Is U.S. Manufacturing Really Declining?" www.stlouisfed.org. April 11, 2017. <https://www.stlouisfed.org/on-the-economy/2017/april/us-manufacturing-really-declining>.

⁹ "National Strategy for Advanced Manufacturing," accessed March 23, 2023, <https://www.whitehouse.gov/wp-content/uploads/2022/10/National-Strategy-for-Advanced-Manufacturing-10072022.pdf>.

¹⁰ Wellener, Paul, Victor Reyes, Heather Ashton, and Chad Moutray. 2021. "Creating Pathways for Tomorrow's Workforce Today." Deloitte Insights. May 4, 2021.

<https://www2.deloitte.com/us/en/insights/industry/manufacturing/manufacturing-industry-diversity.html/#measuring-the>.

profitable in the United States. If the U.S. wants to capitalize on and lead in advanced manufacturing, it must focus on a resilient supply chain that ensures access to critical goods.

After decades of outsourcing manufacturing to other countries, the COVID-19 pandemic exposed the vulnerability of U.S. supply chains and the need for a mitigating solution. Unexpected geopolitical crises, such as Russia's invasion of Ukraine, bolster the imperative to secure and strengthen U.S. supply chains. The growing tensions between the U.S. and PRC emphasize the benefits of on-shoring and friend-shoring critical goods to secure U.S., partner, and allied production capacity.¹¹

Key Stakeholders

A collaborative relationship between all advanced manufacturing stakeholders is the foundation for future economic prosperity. U.S. stakeholders include the government, industry, consumers, and academia. A primary vision of the 2022 National Strategy for Advanced Manufacturing is to enhance economic welfare and security.¹² Many stakeholders recognize and appreciate the opportunities associated with advanced manufacturing and view the process as a future opportunity after significant capital investment. Advanced manufacturing will provide a capacity to design, prototype, and manufacture intricate, higher-quality items at a reduced cost compared to traditional manufacturing methods. Advanced manufacturing can build resilience and grow the future workforce. A healthy and adaptable workforce offers Americans stable employment opportunities and provides continuous economic security.

Industry can benefit from advanced manufacturing through improved part performance factors, cost savings, supply chain optimization, and waste reduction. General Electric, for

¹¹ An expanded discussion on supply chains is included in Annex B

¹² National Science and Technology Council. National strategy for advanced manufacturing. Washington, DC. (2022): 1.

example, reduced time to market from nine months to nine days for NASA's Pogo Z-baffle, yielding a 35% cost reduction compared to traditional manufacturing methods.¹³ Industry's next move will be to bring advanced manufacturing more mainstream from the high-end, low-volume technical design space to more familiar, mass-produced parts. Solving this transition will assist industry with solid growth and innovation in the advanced manufacturing space.

Similarly, consumers also stand to benefit from advanced manufacturing technologies. While factors such as costs impact consumer decisions, other areas such as environmental impacts, safety conditions, and product reliability are increasingly influencing U.S. purchasing behavior. Consumer purchasing power should incentivize manufacturers to take full advantage of advanced manufacturing technologies that reduce traditional manufacturing's impact on the environment, material sources, and extraction methods.

Academia is the final stakeholder and retains interests in advancing science and innovation complementing industry. Academia played a significant role in U.S. innovation over the past century. The advanced manufacturing sector is no different. Many current national innovation institutes partner closely with academia to push the boundaries on additive manufacturing, digital twins, and factory of the future concepts. The U.S. government, industry, and consumers benefit from fundamental research breakthroughs. In return, academia benefits from increased government and private corporation funding access.

Concerns about advanced manufacturing must also be addressed. Some influential decision-makers oppose advanced manufacturing technology, especially when it threatens the loss of jobs. While advanced manufacturing can solve productivity issues and allow for prosperity in other areas, there is a distinct recognition that it will require the transition of

¹³ GE Additive. For the ready, take to the skies with proven metal additive solutions. Retrieved on May 8, 2023, from https://www.ge.com/additive/sites/default/files/2020-09/GE_Aerospace_Brochure_8.5x11_R5.pdf.

employment focused on obsolete or more traditional manufacturing methodologies. Elected officials serving their constituents may be hesitant to support advanced manufacturing technologies or a new smart factory, especially if it fails to replace traditional manufacturing jobs one-for-one in their districts. However, technological advancement often creates more jobs than it replaces.¹⁴ Government officials may be slow to recognize and understand the future long-term economic benefits of advanced manufacturing compared to the immediate benefits of traditional manufacturing. Votes matter, and constituents want to avoid unemployment now for future jobs later. Balancing short-term constituent desires with long-term growth will take the strategic patience of government officials.

Elements within industry may reject incorporating advanced manufacturing processes due to the significant investment required to convert from traditional manufacturing. If industry continues to see a higher return on investment incorporating advanced manufacturing practices, at least in part, industry will invest more significant resources into advanced manufacturing infrastructure. There is also the need for more trained workers and the expected gap of future workers over the next ten years. The decision to convert to advanced manufacturing must deal with the risks of significant upfront infrastructure costs and the uncertainty if there will be enough trained workers. Despite these risks, the government should assist in adopting advanced manufacturing because of its potential benefits for national security and economic prosperity.

Strategic Analysis

Advanced manufacturing is not an industry but a set of processes and technologies used by various industries. Two frameworks and evaluating currently supported industries in

¹⁴ Adi Gaskell, “Does Automation Result in More Jobs Being Created?,” Forbes, September 2, 2021, <https://www.forbes.com/sites/adigaskell/2021/09/02/does-automation-result-in-more-jobs-being-created/?sh=39b65bdd63d0>.

advanced manufacturing were used to analyze the industry and inform strengths, weaknesses, opportunities, and threats (SWOT). The first tool used was the Structure-Conduct-Performance (SCP) Framework. It explored the relationships between these three factors, their effects on the advanced manufacturing industry, and why it operates as it does.¹⁵ The second tool is Porter's Diamond to assess national competitiveness. It examined and compared the structure of different nations' advanced manufacturing industries. Finally, looking at supported industries provided ideas to help build policies to further the adoption of advanced manufacturing.

Structure-Conduct-Performance Analysis

The structure of companies is driven heavily by feedback from the conduct and performance aspects of the framework. The manufacturing industry is not concentrated and is in a monopolistic competition market due to the current structure of many large conglomerates mixed with smaller corporations across various manufacturing-related sectors making differentiated products (many firms, similar but not identical products). Competition drives constant innovation and can assist with the challenges of adopting advanced manufacturing. Though competition is expected to increase, the adoption of advanced manufacturing faces substantial challenges due to current economic scale limitations and the multitude of substitute processes and technologies.

There are significant barriers to entry for companies converting or building a factory with advanced manufacturing aspects, primarily the cost. Companies fail 50-75 percent of the time when making the transition because of the impacts on conduct and performance.¹⁶ Whether

¹⁵ "Enduring Ideas: The SCP Framework," McKinsey and Company, 1 July 2008. <https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/enduring-ideas-the-scp-framework>

¹⁶ Sukathong, Sakonphot, Poonpong Suksawang, and Thanakron Naenna. 2021. "Analyzing the Importance of Critical Success Factors for the Adoption of Advanced Manufacturing Technologies." *International Journal of Engineering Business Management* 13 (January): 184797902110550. <https://doi.org/10.1177/18479790211055057>.
[/doi/pdf/10.1177/18479790211055057](https://doi.org/10.1177/18479790211055057)

adopting a factory of the future concept, using 3-D printing machines, or integrating digital twin technology, they all come at a significant cost to a company. The abundance of market alternatives available to companies to consider when transitioning to advanced manufacturing processes provides an initial economic edge to the customer. Advanced manufacturing processes also require adopting different infrastructure requirements due to the additional utility and cyber demands. Reducing the failure rate should speed up advanced manufacturing adoption and change the industry structure of high-risk and high-entry barriers to one that invites intense competition and grows advanced manufacturing, positively impacting the U.S. economy.

The conduct of manufacturing companies is focused on financial metric performance and associated returns (i.e., strategy). The high cost of capital for infrastructure and machines makes product pricing extremely important for companies using advanced manufacturing. Companies are focused on resilient supply chains to reduce risks and production costs. Many companies manufacturing 3-D printers also develop proprietary raw materials to help new companies reduce vulnerabilities, logistical costs, and production speed. Advanced manufacturing processes are relatively new and often proprietary to the company developing the technology with limited government regulation that lags technological advancements. This shapes firms' conduct as they navigate advanced manufacturing integration and implementation.

While advanced manufacturing processes may add more value to an industry, a company, and its shareholders depend on profitability. As companies find ways to increase output and gain market share, they should provide greater ROI and improve performance to drive greater adoption. U.S. companies are typically allowed to fail, increasing their risk when making decisions affecting their bottom line. Short-term performance dependency drives their conduct and business structure within different sectors and industries to provide a competitive advantage.

Advanced manufacturing is unique in that it supports many other industries instead of being overly supported by others. The aerospace, defense, automotive, electronics, and healthcare industries have found a home for advanced processes to strengthen the resiliency of their manufacturing base. Advanced manufacturing also presents an opportunity for many of these industries, particularly defense, to overcome parts obsolescence and diminishing supplier challenges. To increase global competitiveness, the U.S. could take lessons from the previously listed sectors and invest in advanced manufacturing that focuses on semiconductors, pharmaceuticals, and telecommunications.

The possible impacts on supported industries of advanced manufacturing are transformative for U.S. national security and economic prosperity. Breakthrough technologies in a series of fields that could significantly change how the U.S. produces complex, high-value technologies and goods must be fully adopted. Advanced materials, digital production, lightweight composites, 3-D printing, assistive robotics, additive manufacturing, artificial intelligence, and bio-fabrication offer breakthrough production paradigms that can leapfrog the U.S. manufacturing industry. Investing in these advanced manufacturing techniques and processes can have dramatic downstream economic effects as the U.S. seeks to rebuild a manufacturing sector that has been gutted over the past few decades.

Assessment of National Competitiveness (Porter's Diamond)

To assess national competitiveness, Michael Porter's Diamond framework was applied against the U.S., Japan, and China, in the context of the advanced manufacturing industry.¹⁷ China was selected due to its strong economy and the U.S. competition with the PRC. Japan offers an established economy in the Indo-Pacific region, is a close U.S. ally, and presents

¹⁷ Michael E. Porter, "The Competitive Advantage of Nations," *Harvard Business Review*, March-April 1990, <https://hbr.org/1990/03/the-competitive-advantage-of-nations>.

unique challenges of resource dependency. Russia was not considered in this research for three reasons. First, the Russian manufacturing sector has steadily lost ground over the previous 30 years relative to other developed nations. Second, limited Russian investment in traditional manufacturing leaves them ill-positioned to explore advanced manufacturing. Third, the Russian invasion of Ukraine spotlighted existing manufacturing issues within the Russian economy (and their shrinking GDP) and prevented any significant focus by the Russian government on how to allocate any appreciable effort towards advanced manufacturing.

Comparing the U.S., the PRC, and Japan through Porter's Diamond framework provides a more holistic look at the advanced manufacturing space. The framework looks at factor conditions, demand conditions, related and supporting industries, and the firm strategy, structure, and rivalry-related and supporting industries. The role of chance was intentionally left out of the individual country assessments. It was not included by Porter initially either. It is assumed that "random" acts are going to happen. They may be artificial in the case of war or hostile policies. They could be natural disasters. No government can prepare for every random act. Instead, each country needs to decide the most probable events they will face and build flexibility in response to each act, whether artificial or natural disaster. The three countries listed have met significant events over the last 20 years and have been flexible enough to emerge from the challenge and regain lost footing. There is not much appreciable difference between the three countries, and each is assumed to deal with future "chance" events as previously with no significant long-term impact on their current trajectory dealing with advanced manufacturing.

United States

Technological superiority is a defining factor of U.S. hegemony and economic might. A push to advance America's manufacturing sector through the adaptation and integration of

evolving technologies is leading to the emergence of smart factories and the broader application of additive manufacturing and digital design. Applied appropriately, advanced manufacturing could allow America to improve its leading economic position and international influence as the pacesetter for manufacturing technology innovation.

Factor Conditions. Advanced manufacturing requires a technical labor force, one of America’s greatest assets, and offers a U.S. advantage over competitors. This condition implores American firms to invest in attracting and retaining skilled workers, offering a potential boon for continued national development in advanced manufacturing. Conversely, experts note, “[skilled labor] can be a barrier to entry for new companies without the resources to hire and train the necessary workforce.”¹⁸ Universities, public schools, and innovation institutes are collaborating in the advanced manufacturing space and helping foster enthusiasm for industry careers. The domestic higher education system lacks high numbers of science, technology, engineering, and mathematics graduates. This leads to a disproportionately low number of U.S. citizens obtaining advanced degrees in these areas, impacting the U.S.’s ability to adopt advanced manufacturing. While a skilled workforce strongly supports America’s competitive edge, tailored federal policies can further this strategic advantage.

Demand Conditions. Advanced manufacturing reflects America’s decades-long pivot away from the dirty, dark, and dangerous perceptions of traditional manufacturing. Modern demands dictate smart factories with greater automation, less manual labor, and more efficient workspaces. The adoption of factory automation is one indicator that the benefits of smart

¹⁸ Vlad Khaustovich, “3D Printer Manufacturing in the US,” IBIS World, February 2023, accessed May 5, 2023, <https://my.ibisworld.com/download/us/en/industry-specialized/4428/1/0/pdf>, 23.

factories satisfy the demand for advancement in manufacturing environments and technology.¹⁹ For example, Deloitte and Siemens Digital Industries Software joined forces to promote smart factories and solutions through an experience center demonstrating “features [of] a fully functional production line and hands-on labs for developing smart factory capabilities.”²⁰ While the manufacturing industry benefits directly from clean and less wasteful operations, broader demand conditions are met by moving toward more eco-friendly factories.

Related and Supporting Industries. Supply chains support advanced manufacturing and are imperative to the industry’s function and overall competition. Considering additive manufacturers in particular, firms “only [have] a small number of raw material suppliers, which means most manufacturers experience the same fluctuations in the price of inputs.”²¹ The rising costs of materials and the transport of goods contribute to high prices for industrial printers. While industry supply chains are typically vertical, pockets of regional, horizontal clusters throughout the U.S. show promise in relieving the impacts of supply costs on additive manufacturers. Extending this impact beyond limited geographic regions requires more significant investment.

Supporting national agencies, such as Manufacturing USA, and regional incubators, such as mHub, provide venues for start-ups and small businesses to collaborate and progress. This benefits both individual companies and the large industrial base. These institutions are integral to developing the workforce and connecting local businesses with prospective employees. They

¹⁹ “Global Smart Factory Market Report: 2022-2027,” EMIS, 2022, accessed May 5, 2023, https://nduezproxy.idm.oclc.org/login?url=https://www.emis.com/php/search/docpdf?pc=XX&sv=&doc_id=770346087&numresult=&embedpdf=download , 141.

²⁰ “Global Smart Factory Market Report: 2022-2027,” EMIS, 2022, accessed May 5, 2023, https://nduezproxy.idm.oclc.org/login?url=https://www.emis.com/php/search/docpdf?pc=XX&sv=&doc_id=770346087&numresult=&embedpdf=download , 142.

²¹ Vlad Khaustovich, “3D Printer Manufacturing in the US,” IBIS World, February 2023, accessed May 5, 2023, <https://my.ibisworld.com/download/us/en/industry-specialized/4428/1/0/pdf> , 22.

assist local high schools and universities in identifying labor gaps in the industry. Partnerships with higher education institutions foster technological advancements, such as further identifying new additive materials and technologies to refine current processes. These innovative and collaborative relationships set America apart from nations where the environment and culture prohibit symbiosis.

Firm Strategy, Structure, and Rivalry. Advanced manufacturing's nascency elevates the competitive value of strategy and structure over rivalry. The advanced manufacturing industry's structure is framed by high capital investment for new entrants, with high-profit margins for those who clear initial cost hurdles. New entrants should focus on product differentiation as the actual value of advanced manufacturing. Profits will likely be realized through niche, specialized products versus high-volume and standardized applications. The conditions are rife for firms with disruptive advanced technology, materials, and processes.

While rivalry is low because advanced manufacturing is not yet widely accepted, competition exists as firms seek to take advantage of low concentration levels. "No companies are able to achieve disparate advantages from economies of scale," adding pressure on firms to innovate and differentiate themselves.²² This structural condition should be considered holistically to ensure that small, niche firms maintain the opportunity to grow and compete with large businesses, which have the advantage of economies of scale across business components.

Japan

An aging workforce focused on efficiency innovations over disruptive innovations shapes Japan's industrial culture. It is a society overly dependent on imports to fuel its supply chains

²² Vlad Khaustovich, "3D Printer Manufacturing in the US," IBIS World, February 2023, accessed May 5, 2023, <https://my.ibisworld.com/download/us/en/industry-specialized/4428/1/0/pdf>, 22.

and energy needs. If Japan can adopt advanced manufacturing as a disrupter and solution to supply chain issues, Japan could improve its position as a global economic powerhouse.

Factor conditions. Japan possesses a highly skilled engineering and manufacturing workforce that prioritizes quality and craftsmanship, reinforced by an education system emphasizing STEM education. Institutions like the Advanced Institute of Industrial Technology and the National Institute of Advanced Industrial Science and Technology support the country's robust research and development infrastructure. This significantly advances 3D printing, additive manufacturing, digital design, and smart manufacturing technologies. Japan's R&D budget of \$182.2 billion in 2022 is the third highest in the world.²³

Despite its heavy investment in R&D today, Japan could experience diminishing influence due to declining research productivity and rising debt burdens. Japan appears to lag in university rankings, the number of cited post-graduate research papers, and its drop in doctoral candidates.²⁴ Japan is grappling with the highest level of public debt among advanced economies, surpassing 225% of its GDP. This may curb Japan's ability to continue substantial investment in advanced manufacturing.²⁵

While Japan's highly skilled workforce and robust R&D investments are arguably strengths, the nation must contend with significant demographic and productivity challenges. Japan's demographic trajectory, marked by a high life expectancy and low birth rate, results in a contracting workforce and escalating social welfare costs, placing strain on economic growth and

²³ "Top Countries by R&D Expenditure 2022," Statista, accessed May 7, 2023, <https://www.statista.com/statistics/732247/worldwide-research-and-development-gross-expenditure-top-countries/>.

²⁴ "Japan Tries—Again—to Revitalize Its Research," accessed May 7, 2023, <https://www.science.org/content/article/japan-tries-again-revitalize-its-research>.

²⁵ "Japan General Government Gross Debt to GDP - 2022 Data - 2023 Forecast," accessed May 8, 2023, <https://tradingeconomics.com/japan/government-debt-to-gdp>.

fiscal stability.²⁶ Advanced manufacturing technologies are crucial to address workforce shortages caused by Japan's aging population and the need to increase productivity.²⁷

Concurrently, Japan's productivity growth lags behind other developed economies, despite the nation's skilled workforce.²⁸ This stems from inefficient resource allocation, a persistent focus on traditional industries, and an investment deficit toward digitalization and innovation. Additionally, Japan's ongoing gender inequality issues, reflected in the underrepresentation of women in high-wage positions, further restrict its economic growth.²⁹

Demand conditions. A McKinsey Global Institute report emphasizes that Japan's advanced manufacturing sector is a significant source of its signature exports, including automotive, industrial machinery, and electronics.³⁰ The country's mature and technologically advanced manufacturing industry, driven by the “Kaizen” principle, demands high-quality products and has cultivated a culture dedicated to relentless and continuous improvement.³¹ As a result, Japan's interest in advanced manufacturing has grown due to the need for more efficient manufacturing processes and smart manufacturing technologies. As advanced manufacturing grows worldwide, Japan is expected to continue to adapt and find ways to innovate efficiency with the processes.

²⁶ The Economist. “The Challenges of Japan’s Demography.” The Economist. The Economist, November 26, 2018. <https://www.economist.com/the-economist-explains/2018/11/26/the-challenges-of-japans-demography>.

²⁷ 262, “Japan Advanced Manufacturing,” accessed May 7, 2023, <https://www.trade.gov/market-intelligence/japan-advanced-manufacturing>.

²⁸ Martin Neil Baily, Barry P Bosworth, and Siddhi Doshi. “Productivity Comparisons: Lessons from Japan, the United States, and Germany.” Brookings. Brookings, January 22, 2020. <https://www.brookings.edu/research/productivity-comparisons-lessons-from-japan-the-united-states-and-germany/>.

²⁹ Statista. “Topic: Gender Equality in Japan.” Statista, 2022. <https://www.statista.com/topics/7768/gender-equality-in-japan/#topicOverview>.

³⁰ McKinsey & Company, “The Future of Japan: Reigniting Productivity and Growth,” MGI Report (Tokyo: McKinsey Global Institute, March 2015), <https://www.mckinsey.com/~media/mckinsey/featured%20insights/Employment%20and%20Growth/How%20a%20private%20sector%20transformation%20could%20revive%20Japan/MGI-Future-of-Japan-Full-report-March%202015-03-2017.ashx>.

³¹ A Kaizen blitz, or kaizen event, is a short-term improvement project designed to accomplish significant results in process management quality issues. (<https://safetyculture.com/topics/kaizen-continuous-improvement/>)

Related and supporting industries. While Japan boasts a solid supplier base in materials, automation, and robotics, it must be noted that the nation is heavily reliant on importing natural resources. Considering this reliance on imported resources, the adoption of advanced manufacturing technologies like additive manufacturing is seen as a strategic move to reduce waste and mitigate climate impact. Furthermore, Japan's robust information and technology industry underpins digital design and smart manufacturing, further strengthening its advanced manufacturing capabilities. Japan is primed to increase supporting industries as its advanced manufacturing sector grows.

Firm strategy, structure, and rivalry. Japan has traditionally focused on innovation and technology by finding higher efficiency processes. In terms of 3D printing and additive manufacturing, Japan has many established and new companies providing 3D printing machines and materials. The country also strongly emphasizes digital design, such as Honda and Mitsubishi Electric leveraging digital technologies in their manufacturing processes. In terms of smart manufacturing, Japan is well-positioned with its focus on automation and robotics, which can benefit from integrating factories of the future and AI technologies. However, competition from other advanced manufacturing countries may challenge Japan's advanced manufacturing, given its deference to current market leaders.

China

The PRC has struggled to overcome the middle-income gap as it continues its fast rise to be a global leader. The PRC's authoritarian government allows great control to dictate industry priorities and conduct. Such control makes it possible for the PRC to attain intellectual property (IP) by non-traditional and extremely rapid means, which positions China to develop and adopt advanced manufacturing capability quickly if they can train their workforce with the required

skills relative to competitors. Research and development and overall attainment of IP determine who will gain and maintain an advantage in this space.

Factor Conditions. One of China’s critical factors is the available workforce. The PRC is trying to simultaneously solve the shrinking working-age population and rising wages as they transition from a developing to a developed nation.³² Efforts over the past 40 years have not yielded strong results to reverse the population's decline. China must solve the decline or find new ways to retain and grow productivity based on a smaller workforce to remain economically competitive globally.

Another critical factor is the strong growth in GDP over the last 30 years. The PRC transformed its economy in the last half of the 20th century and is now a global powerhouse. The PRC leveraged its large workforce and ability to get companies to shift manufacturing to China to fuel its strong growth. Membership in the World Trade Organization further cemented gains at the beginning of the 21st century. It assisted China’s rise from a developing economy into one poised to transition to a “developed” economy.³³ China’s strong economic growth primed it for a shift to investments in research and development, organizational expansion, and equipment modernization.

The CCP is another factor in China’s booming economy. The ability of the government to quickly pivot and shift the population’s priorities provides the PRC with opportunities to adjust rapidly to emerging conditions. Specifically if the PRC desires to increase the adoption of advanced manufacturing in China. However, this same strength becomes a liability when

³² Heidi Heimberger and Karaulova, Maria, “Advanced Technology Landscape and Related Policies in China,” *Advanced Technologies for Industry, International Reports*, May 2021, accessed May 12, 2023, https://ati.ec.europa.eu/sites/default/files/2021-07/Advanced%20technology%20landscape%20and%20related%20policies%20in%20China_0.pdf , 20.

³³ “Statistical Annex,” 2022, https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/WESP2022_ANNEX.pdf.

decisions are rash, made to keep the CCP in power and prioritize external factors over the internal needs of the Chinese people.

Demand Conditions. The PRC has established a foothold in the entry-level 3D printer segment, offering low-cost systems that have enabled an unprecedented number of firms to enter the 3D printing industry.³⁴ While the U.S. and Germany have the technological lead, China's additive manufacturing industry has expanded significantly.³⁵ There is also growing demand for digitization as China increases its technology capability. For example, the manufacturing hub in Guangdong province alone is home to nearly three million industrial companies.³⁶ Only 15 thousand of the three million companies in Guangdong have achieved digital transformation, and only half a million companies have gained access to cloud services.³⁷ This leaves 2.5 million companies yet to access the cloud and almost all Guangdong companies to digitally transform. This indicates a strong opportunity for digitization over the next decade.

Related and Supporting Industries. There are few Chinese industries not touched, at least in part, by technologies in advanced manufacturing. Whether through additive manufacturing, factories of the future, or digital design, many industries within China will benefit from increased advanced manufacturing processes. The CCP's advanced manufacturing prioritization has led to the rise of private-sector companies and the expansion from the domestic market into the global arena. Local governments and official research institutes play an essential role in supporting the industry ecosystem, with the state council providing guidelines for

³⁴ Davide Sher, 20+ Chinese 3D printing companies you'll need to know in 2022, December 27, 2021, <https://www.voxelmatters.com/20-chinese-3d-printing-companies-youll-need-to-know-in-2022/>

³⁵ Daniel Berger, Marco Beba, Additive Manufacturing in China, chrome-extension://efaidnbnmnnibpcajpcglclefindmkaj/https://eac-consulting.de/wp-content/uploads/2021/03/Article_Additive-Manufacturing-in-China_Update-2021.pdf

³⁶ China's main production base hastens digital transformation, China Daily | Updated: May 7, 2023.

³⁷ China's main production base hastens digital transformation, China Daily | Updated: May 7, 2023.

research policy.³⁸ In context, the PRC now has more companies on the Fortune Global 500 list than the U.S., with nearly 75 percent of those companies being state-owned enterprises.³⁹

The PRC must overcome long-standing economic and cultural factors to meaningfully leverage advanced manufacturing. China faces the opposite problem from the US. While America outsourced low-value production that is still required to fuel its advanced, high-value economy, China never developed the capability for the latter and, thus, must create it anew. China relies on imports for high-technology core items such as computer central processing units and other semiconductors.⁴⁰ Innovation efforts beyond generic products at the bottom of the value chain are still in their infancy. The PRC requires increased investments in infrastructure, digitization, and a shift in the workforce to implement any advanced manufacturing capability.

Firm Strategy, Structure, and Rivalry. Unlike capitalistic societies, the PRC continues to benefit from CCP-controlled resources to strengthen its economic standing on the world stage. The CCP actively participates in the country's economic pursuits and leverages its working-age population of almost 1 billion people to support its objectives. In recent decades these factors have combined to make the PRC a global manufacturing colossus. Xi Jinping, Chairman of the CCP, continues to urge his comrades to focus on manufacturing and technology, which he described as the “real economy,” and to cultivate talent to address China's demographic crisis.⁴¹

³⁸ Evaluating Innovation in China, China's Innovation Ecosystem, World Economic Forum, August 2016, chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www3.weforum.org/docs/WEF_GAC_On_China_Innovation_WhitePaper_2016.pdf, P. 4.

³⁹ Blanchette, Jude. “Confronting the Challenge of Chinese State Capitalism.” Center for Strategic & International Studies. Accessed on May 15, 2023 at <https://www.csis.org/analysis/confronting-challenge-chinese-state-capitalism>.

⁴⁰ Evaluating Innovation in China, China's Innovation Ecosystem, World Economic Forum, August 2016, chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www3.weforum.org/docs/WEF_GAC_On_China_Innovation_WhitePaper_2016.pdf, P. 4-5.

⁴¹ Mandy Zuo and He Huifeng, China Economy, Chinese President Xi Jinping says economic growth plans must focus on manufacturing and technology, South China Morning Post, May 6, 2023, <https://www.scmp.com/news/china/politics/article/3219645/chinese-president-xi-jinping-says-economic-growth-plans-must-focus-manufacturing-and-technology>.

The ultimate benefits and downfalls of this level of central control of the advanced manufacturing environment remain to be seen.

The PRC is performing well in advanced manufacturing-related patents such as “infrastructure, data platforms, production modeling, manufacturing cloud, and other applications”⁴² Other countries seek opportunities in advanced manufacturing to complement a future workforce, achieve cost savings through additive manufacturing, or leverage digital twins to supplement prototypes, designs, or maintenance. On the other hand, the PRC is positioned to benefit the most from implementing advanced manufacturing technologies should they use state sponsorship, their available workforce, and accessible equity to invest and even leap forward from traditional manufacturing practices to cutting-edge, advanced manufacturing technologies. While traditional manufacturing is a crucial element leading to the PRC’s increased power over recent decades, the country could use advanced manufacturing technologies to maintain or improve its global economic might.

SWOT Analysis

Based on the strategic analysis section of the SCP and Porter’s Diamond, some strengths, weaknesses, opportunities, and threats emerged, requiring discussion to drive toward recommended future actions. To harness the benefits of advanced manufacturing, the U.S. must leverage its strengths to seize available opportunities while mitigating weaknesses and threats. U.S. advanced manufacturing strengths include an established synergy between government, industry, and academia, a free-market economy encouraging diverse innovation, and increasing investment in industrial policy. First, government, industry, and academia’s positive relationship allow for the exchange of ideas and provides incubator spaces for innovation. Maintaining this

⁴² Zhu Shenshen Chinese firms have more smart manufacturing patents applications June 29, 2021. <https://www.shine.cn/biz/economy/2106291300/>

relationship is vital to secure continued advancement in this space. Second, a free-market economy incentivizes innovation that may become stifled in a command-directed structure.⁴³ The U.S. economic model promotes new applications for advanced manufacturing technology while conserving critical resources. Third, the Inflation Reduction Act and CHIPS and Science Act demonstrates tangible actions to invest in the U.S. manufacturing industry.⁴⁴ These pieces of legislation promote workforce development through STEM education and provide firms with funds to retool legacy manufacturing processes through tax credits. The U.S. should immediately leverage the listed opportunities to strengthen advanced manufacturing domestically.

Key weaknesses for U.S. implementation of advanced manufacturing include insufficient human capital, the venture capital model, a risk-averse corporate culture in established firms, and a need for recognized standards. The current American manufacturing workforce needs more training for emerging jobs. Training is required to close the gap and provide current and future workers with the right skills. In addition to workforce limitations, the U.S. venture capital model isn't ideal for advanced manufacturing startups due to significant capital expenditures to grow a company from the start-up stage. Venture capitalists prefer scenarios where they can scale with little to no money invested.⁴⁵ Lack of private capital contributes to the "valley of death" scenario where new manufacturing technology fails to mature and achieve market presence.

All stakeholders benefit from accepted industry standards, a shortfall that limits the potential of U.S. advanced manufacturing writ large. The lack of standards increases the risks for

⁴³ Regina M. Abrami, William C. Kirby, and F. Warren McFarlan, "Why China Can't Innovate," *Harvard Business Review*, March 1, 2014, <https://hbr.org/2014/03/why-china-cant-innovate>.

⁴⁴ Joseph Biden. Executive Order 14080. "Implementation of the CHIPS Act of 2022." *Federal Register* 87, no. 167 (August 25, 2022). <https://www.federalregister.gov/documents/2022/08/30/2022-18840/implementation-of-the-chips-act-of-2022>.

⁴⁵ David Adler, "Financing Advanced Manufacturing: Why VCs Aren't the Answer," *American Affairs Journal* (blog), May 20, 2019, <https://americanaffairsjournal.org/2019/05/financing-advanced-manufacturing-why-vcs-arent-the-answer/>.

companies investing in capital-intensive advanced manufacturing infrastructure. Additionally, certification of additively manufactured parts is notoriously protracted. Many companies are not large enough to wait on profits for part certification, ultimately dissuading investment.

The U.S. can bolster its advanced manufacturing base with the help of its extensive network of partners and allies. With coordinated efforts and like-minded strategies, allies can command advanced manufacturing market share and permeate emerging technology to new markets. Collective supply chains and shared standards with partners and allies increase opportunities for the U.S. to remain the partner of choice for other nations. America's success partially depends on its ability to develop an advanced manufacturing ecosystem. With a significantly smaller population than China, the U.S. should use advanced manufacturing to increase workforce productivity. Similarly, the U.S. can use advanced manufacturing technology to gain competitive advantages within emerging markets through digitization, such as regenerative healthcare services and in-space manufacturing. The U.S. can own the future by investing in the next generation of production technologies that can enable more advanced, higher-value products.

Significant threats to America's advanced manufacturing technology include supply chain distribution and IP theft. For example, the PRC controls access to many sources of rare earth metals used in aerospace additive manufacturing.⁴⁶ The U.S. should maximize critical supply chain independence from competitors and invest in technologies to recycle waste material from legacy production methods. Likewise, the PRC's well-documented aggressive and coercive

⁴⁶Nicholas LePan, "Rare Earth Elements: Where in the World Are They?," Visual Capitalist, November 23, 2021, <https://www.visualcapitalist.com/rare-earth-elements-where-in-the-world-are-they/>.

acquisition tactics jeopardize U.S. and allied businesses dependent on their IP for profitability. Advanced manufacturing materials and processes require cradle-to-grave protection.

Policy Recommendations

The role of policy in government is to incentivize or disincentivize certain behaviors and can help achieve desired end states. After thoroughly exploring the strategic environment, analyzing the current state of advanced manufacturing, and deriving all the facts, issues, and factors into a SWOT analysis, four policy recommendations appear to offer the most benefit. To provide the greatest impact on global security, economic prosperity, and promulgation of American values, the U.S. government should implement policies to ensure a robust and capable manufacturing workforce, provide regulatory oversight on additive manufacturing standards, leverage advanced manufacturing to ensure access to critical goods, and strengthen the U.S. manufacturing footprint through IP sharing and protection.

Policy 1: Bolster the American Workforce

The U.S. must train, educate, and grow a robust and capable workforce to meet modern, expanded manufacturing skill demands, increase productivity, and close the skillset gap to adopt advanced manufacturing further. As part of the U.S. Department of Commerce, Manufacturing USA can best lead this interagency and interbranch effort. The Commerce Department, in stride with the Department of Education, should advocate to the U.S. House Committee on Education and Workforce to target 16 to 29-year-old U.S. citizens to enter careers in advanced manufacturing. Specifically, the departments should push for expanded training and education, career path development and pipelines, and grow a modern manufacturing workforce to close the unfilled and unskilled demand gap through two outreach programs.

First, an expanded Advance Manufacturing Technology Program (AMTP) in middle school, high school, and community colleges could reap incredible benefits. Expanding existing

promotional efforts of various Institutes and Manufacturing Extension Partnerships (MEPs) by targeting middle through high school students and reintroducing an Advance Manufacturing Technology Program (AMTP) in schools across America. With support from the Innovation Institutes and MEPS, AMTP would consist of a track allowing students to enter the program voluntarily. Starting in middle school, the program consists of regular studies, combined with AMTP classes. Students are then trained in multiple areas of advanced manufacturing over multiple school years. Certifications in the different areas of advanced manufacturing are achieved before graduation, preparing the student to either immediately enter the workforce or further their advanced manufacturing education in a community college or with an advanced degree. The Commerce Department should solicit and encourage industry sponsorship through collaborative partnerships with community colleges to refine and tailor curricula to specific industry needs. Industry sponsorship can include matching funding by state and local governments to further strengthen industry, government, and academic relationships. Companies would partner and subsidize the community college's advanced manufacturing programs and could hire from a pool of trained applicants. Before the students graduate, they could complete a summer internship at the company to see if it's a good fit or if they'd prefer a different path.

Secondly, the Executive Branch departments should develop a generationally relevant information campaign to redefine the perception of the manufacturing sector. This information campaign would strive to rebrand the sector, targeting teenagers through young adults. It would highlight the industry's high-tech, fast-paced, innovative nature and the potential for well-paying, rewarding jobs to make relevant and exquisite parts and products. Messaging highlights the importance of the parts and products that can be impactful in every sector of American life, from the environment to aviation, space, or defense. Advertising on modern media platforms, like

YouTube, with influential figures such as Dwayne “The Rock” Johnson or some other easily recognized and relatable public figure could impact the perception of manufacturing and attract a diverse range of talent.

As with any policy implementation or refinement, it must be funded and comes with some risk. Funding for these two efforts can come from many sources. For example, a portion of the \$1.26 billion in unused funds from The American Rescue Plan (ARP) authorized for education could be earmarked to help execute this policy.⁴⁷ Growing an advanced manufacturing workforce by changing educational curricula imposes a political risk, as some constituents may prefer something else. Many parents may view the change through the old manufacturing paradigm. This is the critical linkage to the House Committee on Education and Workforce to mitigate risk. By incorporating citizens’ representatives early in the policy implementation, efforts can be focused on more appropriate regions of the country where it is more likely to be embraced. Failure to implement policies to develop a robust and capable workforce could result in decreased national economic prosperity and opportunity, diminished means to secure the American people, and shift global economic growth to rising powers such as the PRC.

Policy 2: Additive Manufacturing Standards

Standardizing products and processes in the U.S. advanced manufacturing, specifically, the additive manufacturing industry, are nascent, compliance is voluntary, and no regulatory body is solely tasked with oversight. When Americans buy ground beef, they know the U.S. government, through the U.S. Department of Agriculture (USDA), has guaranteed that meat is of a certain quality and sourced from cows. When partners and allies buy U.S. defense equipment, they know it has met the highest levels of DoD quality control. There is no such guarantee in

⁴⁷ Committee for a Responsible Federal Budget, “COVID Money Tracker,” COVID Money Tracker, 2023, <https://www.covidmoneytracker.org/>.

products made via additive manufacturing. The American National Standards Institute (ANSI) aims to generate consensus amongst industries for standards, but it is not a regulatory body.⁴⁸ The American Society for Testing and Materials (ASTM) guides aspects of additive manufacturing but does not guarantee the safety of end products.⁴⁹ Companies follow ANSI and ASTM voluntarily and are incentivized but not required to ensure product safety to maintain consumer confidence. Americans expect companies to provide safe products but demand that the U.S. government enforce those standards.

Standards provide consumer confidence and underpin economic prosperity through process control, common architectures, and reduced cost barriers to technology adoption that spur innovation. The U.S. Founders identified the importance of standards by mandating that Congress “fix the Standard of Weights and Measures.”⁵⁰ The Biden Administration recently built on generations of U.S. standard setting with the National Standards Strategy for Critical and Emerging Technology. Glaringly absent from the Standards Strategy was any mention of manufacturing, traditional or advanced.⁵¹ In 2016, America Makes and ANSI established the Additive Manufacturing Standardization Collaborative (AMSC) to collaborate on industry-accepted standards to facilitate growth.⁵² As advanced manufacturing technologies mature, U.S.

⁴⁸ Joseph J. Lazarra, “Safeguarding: Are ANSI Standards Really Voluntary?,” *Occupational Hazards Magazine* (December 2004), https://www.assp.org/docs/default-source/standards-documents/safeguarding-are-ansi-standards-really-voluntary.pdf?sfvrsn=87cdb147_2#:~:text=Technically%2C%20ANSI%20standards%20are%20considered,written%20as%20laws%20or%20regulations.

⁴⁹ ASTM, “Additive Manufacturing Standards,” Standards Products, accessed May 8, 2023, <https://www.astm.org/products-services/standards-and-publications/standards/additive-manufacturing-standards.html>.

⁵⁰ U.S. Constitution, art I, sec 8, cl 5.

⁵¹ Joseph R. Biden, “US Government National Standards Strategy for Critical and Emerging Technology,” The White House, May 4, 2023, <https://www.whitehouse.gov/wp-content/uploads/2023/05/US-Gov-National-Standards-Strategy-2023.pdf>.

⁵² American National Standards Institute, America Makes and ANSI Additive Manufacturing Standardization Collaborative,” Standards Coordination, accessed on May 15, 2023, <https://www.ansi.org/standards-coordination/collaboratives-activities/additive-manufacturing-collaborative>.

standards organizations like NIST, ANSI, and ASTM must lead with standards adaptive to rapid changes while still ensuring the quality of end products acceptable to international markets.

The U.S. government must shepherd the development of additive manufacturing standards and inform the supporting industries and the U.S. population of its focus on safety and reliability by integrating the Consumer Product Safety Commission (CPSC) with AMSC. Simultaneously, the U.S. must explain and advocate our preeminence in additive manufacturing to partners and allies to promulgate U.S. standards in the industry. Under the auspices of the Department of Commerce and in coordination with the AMSC, the U.S. will need a common way forward on regulation that keeps pace with but doesn't hinder technological advancements.

On May 1, 2023, AMSC released its draft roadmap for additive manufacturing standards for public review and comment.⁵³ It is comprehensive, but a process must be established to streamline parts certification as technology rapidly advances, and the government should be integrated to ensure public safety. Government oversight by the CPSC of additive manufacturing is growing, but it should be more collaborative with those that develop the products and standards. Integrating the regulatory aspects of the CPSC with the standards development of AMSC could facilitate the rapid growth of additive manufacturing while maintaining consumer confidence. This will come with an increased CPSC oversight cost but could be funded in the near term with part of the estimated \$50 billion left over from the unspent Coronavirus allocations while longer-term legislation is considered.⁵⁴ The State Department should

⁵³ America Makes and AMSC, "Working Draft: Standardization Roadmap for Additive Manufacturing, Version 3.0," accessed on May 13, 2023, https://share.ansi.org/Shared%20Documents/Standards%20Activities/AMSC/AMSC_23_001_WORKING_DRAFT_AMSC_Roadmap_v3.pdf.

⁵⁴ Catie Edmondson and Madeleine Ngo, "House G.O.P. Eyes Rescinding Unspent Covid Money as Part of Its Fiscal Plan," *The New York Times*, April 20, 2023, <https://www.nytimes.com/2023/04/20/us/politics/republicans-unspent-covid-money-debt-limit.html#:~:text=Estimates%20put%20the%20amount%20of,%2450%20billion%20and%20%2470%20billion.>

concurrently prioritize engagement with key partners and Allies to ensure they are aware of and participate in the collaboration between CPSC and AMSC. This public-private partnership could evolve into a symbiotic relationship between producers and regulators while incorporating other nations in U.S.-led additive manufacturing standards to enable widespread adoption.

The risk of failure to lead in setting the global standards of additive manufacturing is that another nation, like the PRC, will lead. International standards, like nature, abhor a vacuum.⁵⁵ In the absence of U.S. leadership, other countries will fill the void. This is evident in modern areas like 5th-generation (5G) mobile networks. Under the guidance and direction of the CCP, Chinese companies hold one-third of the world's 5G-related patents. This technology, like advanced manufacturing, enables numerous other industries.⁵⁶ The nation that leads the world in setting standards controls that industry and every industry it touches. That provides the opportunity for immense leverage or collaboration with other countries, depending on which way the standard-setter intends to go.

Policy 3: Ensure Access to Critical Goods

Vladimir Lenin said, “Every society is three meals away from chaos.”⁵⁷ The CCP fully understands the sentiment of their Marxist luminary, and the U.S. should heed the word of a man who toppled a world power and built his country on a mass of starving people. In the 21st century, civil society relies not only on food but many other staples, from medicine to semiconductors. As demonstrated during the COVID-19 global pandemic, vulnerable supply

⁵⁵ Marcelo Gleiser, “A Brief History of Nothing,” National Public Radio (NPR), June 6, 2012, <https://www.npr.org/sections/13.7/2012/06/06/154349295/a-brief-history-of-nothing>

⁵⁶ Heeejin Lee, “The US-China ‘Standard-Off’ Over Technology,” East Asia Forum, September 2, 2022, <https://www.eastasiaforum.org/2022/09/02/the-us-china-standard-off-over-technology/#:~:text=Chinese%20companies%20hold%20one%20third,communication%20in%20emerging%20technological%20sectors>.

⁵⁷ <https://www.goodreads.com/quotes/853096-every-society-is-three-meals-away-from-chaos#:~:text=Quote%20by%20Vladimir%20Lenin%3A%20%20Every,three%20meals%20away%20from%20chaos%20>

chains crippled the U.S. economy; meanwhile, the lack of available personal protective equipment threatened the welfare and security of the American people. During this crisis, the U.S. leveraged advanced manufacturing, specifically additive manufacturing, to address unreliable supply chains. Between February 15 and July 15, 2020, U.S. additive manufacturing companies produced more than 38 million face shield parts, 12 million nasal swabs, and 116,000 ventilator parts to address the protective equipment shortage in the early stages of the pandemic.⁵⁸ Using additive manufacturing to address supply chain shortfalls during COVID-19 demonstrates how its processes and products can be used to ensure U.S. security while providing economic prosperity during a time of strife. After decades of offshoring production, the U.S. must prioritize a flourishing additive manufacturing industry to ensure access to critical goods in the event of disrupted supply chains caused by world events, such as another pandemic or even conflict with the PRC.

The U.S. is unlikely to revitalize domestic, large-scale traditional manufacturing due to high costs, a nonexistent workforce, and the need for more infrastructure. It is not enough to strengthen the resiliency of existing global supply chains; instead, the U.S. should leverage small additive manufacturing firms to ensure its ability to produce critical items, if needed domestically. Reliable access to certain manufactured products is essential for U.S. and partner militaries, the medical and energy sectors, and the electronic devices modern society demands. This is illustrated in the Biden administration's identification of critical supply chains in Executive Order 14017 and its associated 100-day review.⁵⁹ This whole-of-government approach

⁵⁸ America Makes. "COVID-19 response: Assessing the role of additive manufacturing in the support of the U.S. COVID-19 response." Accessed at <https://www.fda.gov/media/150614/download> on May 10, 2023.

⁵⁹ White House, "FACT SHEET: Biden-Harris Administration Announces Supply Chain Disruptions Task Force to Address Short-Term Supply Chain Discontinuities," The White House, June 8, 2021, <https://www.whitehouse.gov/briefing-room/statements-releases/2021/06/08/fact-sheet-biden-harris-administration-announces-supply-chain-disruptions-task-force-to-address-short-term-supply-chain-discontinuities>.

to build a resilient supply chain can be enhanced by prioritizing small firms' additive manufacturing capacity and linking these firms with domestic partners through MEPs and crucial international partners and allies through coordination with the U.S. State Department.

The Departments of Defense, Health and Human Services, Energy, and Commerce must collaborate with the Treasury Department to coordinate with the House Committee on Ways and Means to establish tax incentives for small, lower-tier firms to invest in additive manufacturing capabilities. This investment will support the increased economic prosperity of the small firms in steady state times. In the event of a crisis, the increased ability of numerous small manufacturers to additively produce goods could be utilized for critical sectors. In the near term, the Department of Commerce should leverage the existing Supply Chain Resiliency Fund identified in the FY23 Presidential Budget while long-term tax legislation is developed. This provides immediate access to approximately \$5 billion in incentives for small businesses. The time to invest in additive manufacturing to build resilience in the supply chains which support U.S. critical technologies is now, as the nature of the next crisis is unknowable.

Concurrently, the U.S. Department of State should engage with select international partners to establish areas of burden sharing and mitigate shared shortfalls. Areas of collaboration would be country dependent, but the State Department could link the DoD with key Pacific Allies on additive defense production. The Department of Health and Human Services, in coordination with international organizations like Doctors Without Borders, could utilize small firms' additive manufacturing of medical equipment or pharmaceuticals in developing African countries to build goodwill, innovate new use cases, and reinforce the U.S. as the partner of choice worldwide thereby countering the PRC's predatory efforts.

These efforts ensure access to critical goods but are not risk-free, and select stakeholders may meet them hesitantly. For example, some small firms may hesitate to adopt additive capabilities due to perceived low returns on investment, loss of long-standing jobs, or the cost-effectiveness of manufacturing overseas. Some allies and partners may be economically intertwined with China and require further assurances, foreign direct investment, or trade incentives to embrace the opportunities investing in additive manufacturing may have on their economic prosperity and our collective security. Increased small firm additive manufacturing capacity, along with select international partnering, could build resilience in manufacturing that allows the U.S. room to adapt and overcome any future crisis.

Policy 4: Strengthening U.S. Manufacturing Footprint Through IP Sharing and Protection

The U.S. advanced manufacturing sector has the potential to significantly expand its footprint by developing and leveraging the capabilities of small regionally-based manufacturing firms. These firms need more access to large firms' IP, making it hard to reproduce required parts locally. Due to the legal costs of enforcing patents, they are often disincentivized from creating and innovating unique or enhanced designs. To promote economic prosperity and uphold U.S. democratic values, the U.S. government must support small manufacturers by protecting IP and incentivizing large firms to share IP through appropriate compensation models.

The Departments of Commerce and Treasury must leverage economic incentives to promote wider adoption of IP sharing. At the same time, the Department of State must inform and incentivize partners and allies to use American-developed IP in their advanced manufacturing sectors. To begin, the Department of Commerce's U.S. Patent and Trade Office (USPTO) should establish an interagency working group to propose a comprehensive framework for IP protection in advanced manufacturing. This group will include experts from various fields to address the challenges faced by small manufacturing firms. The USPTO should also establish

standardized IP valuation and pricing methodologies, including exploring innovative concepts, such as leasing agreements, through collaboration between the Department of Commerce and industry stakeholders. These guidelines will ensure transparency and fairness in IP transactions, enabling effective IP sharing between large and small firms. Further, the Department of Treasury should work closely with Congress' Joint Committee on Taxation to develop tax incentives encouraging large firms to share their IP with smaller ones. These incentives will promote collaboration and knowledge transfer, fostering a more competitive and innovative manufacturing landscape.

The Department of State should engage with allies and partners, encouraging them to integrate American-developed IP in their advanced manufacturing industries. This will expand the global reach of U.S. manufacturing and ensure that IP is responsibly protected and used in accordance with the values of fair competition. The proposed economic incentives and tax breaks should address potential costs, risks, and gaps to make IP sharing more attractive to large firms, emphasizing the potential for long-term benefits and industry growth. The interagency working group should also develop robust IP protection measures and work with international partners to establish powerful legal frameworks for IP enforcement. The U.S. can strengthen its domestic manufacturing footprint, support the growth of small manufacturing firms, and lead the global advanced manufacturing industry in innovation and collaboration with timely and appropriate tax incentives and international cooperation with like-minded states.

Additional Costs, Risks & Gaps

The most significant cost facing the U.S. is inaction and losing its international influence shaping global institutions towards stability, risking decreased national security, and diminished economic prosperity. The U.S. can continue innovating in its current paradigm, seeking to leverage its robust R&D capabilities. However, there is a significant cost to doing nothing. One

only need hearken back to WWII to understand the gift America received from President Roosevelt, pushing to modernize the American economy before Pearl Harbor. This provided a running start to U.S. manufacturing as WWII consumed other nations that were technologically static at the end of the war compared to where they were at the beginning.

The U.S. cannot risk entering the next event, artificial or natural, static. Instead, it must “fight” to retain its current position of primacy to continue leading partners and allies through the most recent threat to the international order.⁶⁰ The economic gap, and its associated international leverage, are narrowing. If the U.S. seeks to widen the distance between itself and its nearest competitor, then it must begin assimilating advanced manufacturing into current industry. This allows the U.S. to preserve national security, increase economic prosperity, and strengthen relationships with its allies and partners.

Conclusion

Time does not wait for a country to decide its direction. The competition between the U.S. and the PRC continues to heat up. At the same time, the seemingly inevitable march toward conflicts carries on to an ever-quickenning drumbeat. Concerning advanced manufacturing, the U.S. must decide to lead now and secure a dominant economic position for the rising generation. A synchronized effort between government, industry, consumers, and academia can yield further research into the best applications of advanced manufacturing. Not just the best products to produce quickly but the right ones to secure economic prosperity during times of change and supply chain disruption. IP rights cannot be solved at the time of need. A solid foundation of culture change focused on fairly adjusting IP use can build out small “mom and pop” suppliers

⁶⁰ The U.S. has weathered different economic challenges to its position over the last 70 years. The U.S.S.R, Japan, Europe, and now China. It is not our contention the competition must end via conflict. However, the stronger economically positioned nation at the end of the competition will hold leverage to influence the international order most.

positioned to buttress national security manufacturing needs during peacetime, but especially during times of strife. To get there, the U.S. must also educate a new generation of skilled workers trained to operate, innovate, and accelerate all things advanced manufacturing. Finally, the U.S., partners, and allies must steer the international order towards peace and lift all nations who seek to build relationships rather than leverage economic advantage with ill will. Doing this will strengthen U.S. national security, create economic prosperity, and refortify the U.S. position to lead the world in the 21st century and beyond.

Annex A: Implications of BRI on U.S. Advanced Manufacturing

China’s Belt and Road Initiatives (BRI) is branded as benevolent global infrastructure development; however, its manifestation is pervasive, at times exploitative, and reminiscent of the ideologically world-altering Silk Road established over 2,000 years ago. While the Silk Road enabled the spread of goods, ideas, and entire cultures over thousands of miles of previously unconnected terrain, BRI threatens to isolate and indebt vulnerable countries needing economic support.⁶¹ New and upgraded manufacturing capabilities are one facet of BRI that seemingly offers the opportunity for attainable financial gains for BRI countries. However, such capabilities, under Chinese control, are likely to yield significant costs for China’s competitors and almost ensure long-term indebtedness for BRI partners.

What BRI Offers: As of December 2022, BRI includes 148 countries designated by memorandums of understanding (MOU) with China.⁶² Though the initiative emphasizes the benefits for developing countries, endorsements from countries of all income levels (including

Countries of the Belt and Road Initiative

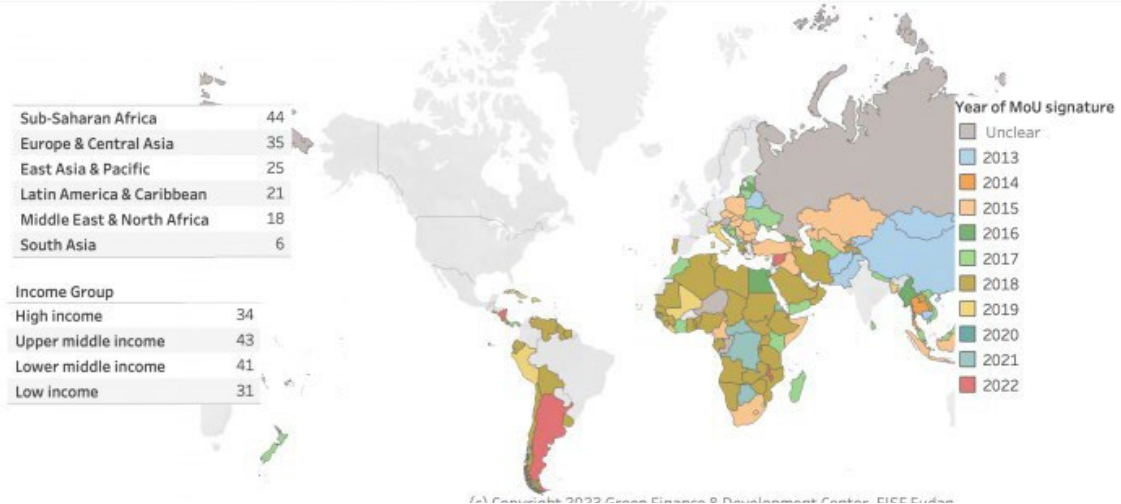


Figure 1: Countries of BRI by MOU Date

18 countries of the European Union and nine countries of the G20) contribute to a vast network with growing influence.⁶³ While several U.S. allies are BRI signatories, a Council on Foreign Relations analysis indicates that “those countries that have refrained from joining BRI are generally more democratic, politically stable, and economically developed than those that have endorsed the initiative.”⁶⁴ Geopolitical relationships significantly influence analyses of why countries join or abstain, but the economic need is a much more objective measure.

BRI is a multi-faceted strategy leveraging the four primary instruments of Chinese national power, diplomatic, informational, military, and economic. Still, the latter is what gives

⁶¹ Andrew Chatzky, James McBride, and Noah Berman, “China’s Massive Belt and Road Initiative,” Council on Foreign Relations (Council on Foreign Relations, February 2, 2023), <https://www.cfr.org/backgrounders/chinas-massive-belt-and-road-initiative>.

⁶² Christoph Nedopil, “Countries of the Belt and Road Initiative (BRI) – Green Finance & Development Center,” Green Finance & Development Center, 2022, <https://greenfdc.org/countries-of-the-belt-and-road-initiative-bri/>.

⁶³ Ibid.

⁶⁴ Andrew Chatzky, et al.

BRI far-reaching appeal. China's economic strength allows it to offer considerable financial support to further the initiative's four broad objectives:

1. Hard Infrastructure development: create and better connect hard infrastructure to strengthen coordination and capabilities.
2. Soft Infrastructure development: encourage trade deals, alignment of regulatory standards, and financial integration.
3. People-to-People Connectivity: cultivate student, expert, cultural exchange, and tourism. Transfer Chinese know-how to support partners.
4. Improve Intergovernmental Communication: better align government policies related to economic development and regional cooperation.⁶⁵

Work in these areas is made possible by enormous (yet officially undisclosed) capital from Beijing via Chinese banks and companies. Institutions such as the Chinese Development Bank and Export-Import Bank of China borrow for minuscule interest rates from the People's Bank of China and lend equally cheaply to Chinese companies, including state-owned enterprises. In turn, those companies, bolstered by cheap capital, offer bids for BRI projects abroad that foreign counterparts cannot compete against. BRI is such a dominant feature of China's national strategy that it was incorporated into the Chinese Community Party's constitution in 2017.⁶⁶ Prominent throughout government and industry, China is adept at leveraging its competitive advantage to bolster and extend the reach of this integral initiative.

China is a powerhouse of traditional manufacturing, drawing from decades of expertise to offer upgrades, advancement, and new manufacturing capabilities to BRI partners. These arrangements often involve joint ventures, technology transfer, or physical infrastructure. Still, the underlying theme is Chinese maintenance of control via outright ownership or ownership of the BRI-host nation's debt. The potential benefits are difficult for beneficiaries to reject. Building an industrial park or a single manufacturing plant in a low-income country offers a chance to attract foreign direct investment and trade, job creation, increased productivity, potential economic diversification, and innovation opportunities.⁶⁷ Beyond traditional manufacturing, BRI has spurred the development of advanced capabilities such as a Chinese-manufactured tunnel-boring machine and novel railroad construction equipment.⁶⁸

More standard advanced manufacturing technologies, such as additive, smart factories, AI, and the internet of things, are not highly integrated into the common BRI basic infrastructure projects; however, they could offer a form of more direct competition with the U.S. and other advanced nations as China leverages BRI for extended economic and political influence worldwide.

What BRI Costs: BRI touts regional integration, increased trade, and economic stimulation across Southeast Asia, the Middle East, Africa, and Europe; however, first and foremost, BRI is President Xi's trademark policy and an integral part of his legacy. Any

⁶⁵ China Power team, "How Will the Belt and Road Initiative Advance China's Interests?," ChinaPower Project, September 11, 2017, <https://chinapower.csis.org/china-belt-and-road-initiative/>.

⁶⁶ Andrew Chatzky, et al.

⁶⁷ China Power Team.

⁶⁸ Stephen Pudner and Xeris Gregory, "How Will China's Belt and Road Initiative Change the World?," Americanbar.org, 2019, https://www.americanbar.org/groups/construction_industry/publications/under_construction/2019/winter2019/china-belt-road-initiative/.

perceived benefits for signatories will only come at the behest of China under the condition that China has first reaped the benefits it desires from the BRI relationship. For example, more reliable roads, ports, and railways across the nearly 150-country BRI network could significantly improve supply chains that the world saw crippled by the pandemic. In reality, this infrastructure will operate at China's discretion, albeit in other countries. Upon completion, many BRI-developed facilities are staffed with Chinese workers and managed by Chinese companies. Further, technology critical to the operation of manufacturing facilities is lent or shared by China but not outright transferred to allow BRI-hosts independent use and manipulation. If China experiences a shortage of supplies, it will leverage the network it created and funded to ensure that it does not go without, no matter the cost to other signatories. Chinese banks do not exercise typical financial discretion to vet BRI projects appropriately; instead, BRI decisions are strategic, creating tangible and intangible pathways that the CCP deems essential or beneficial to President Xi's strategic objectives.

Expanded Chinese influence, power, and economic strength are at odds with U.S. national security objectives. Based on the number of signatories and geographic reach alone, the expanding BRI network appears to be improving China's standing in great power competition. Whether or not it elevates China relative to the U.S. is impossible to say without considering objective metrics over the years. In the context of advanced manufacturing, the cost of BRI to the U.S. and its allies is more discrete. The primary challenge BRI poses is a potentially diminishing pool of suppliers and narrowing supply chains and routes. While advanced manufacturing could make supply chains more resilient, designing and developing advanced manufacturing technology still requires traditional infrastructure and supplies that cannot be replaced. The more control and influence China wields over traditional manufacturing, the more difficult it will become for the U.S. and its allies to pursue advancements and innovation in their capabilities, absent novel strategies.

What To Do About BRI: Through BRI, China seeks economic power and influence to write the rules others must follow. This is not a role that the U.S. and its democratic allies are willing to give up or share with an authoritarian regime. To thwart China's influence, the U.S. needs a strategy that is equally comprehensive and unwaveringly democratic, in juxtaposition to China's overbearing and exploitative BRI tactics. One facet of that strategy should leverage America's competitive advantages in advanced manufacturing.

Capital investment in hard manufacturing infrastructure is difficult to beat, and the U.S. should not compete directly with China's predatory construction and management projects in BRI countries. Instead, drawing from the policies in this report, the U.S. should grow and leverage its skilled workforce, strong supporting agencies, and product differentiation and innovation to gain influence where China is posing competition. Manufacturing workforce transition programs assist the American workforce and offer opportunities for the U.S. to build relationships with other nations by helping them build up their own manufacturing workforce transition programs, strengthening relationships along the way.

Instead of attempting to catch up with China's BRI strategy, which relies heavily on traditional, outdated manufacturing capability, the U.S. must aim to leap further ahead of China's technology and processes with a hyperfocus on using advanced manufacturing to solve access to the most critical products of the supply chain during disruption. Ensuring access to critical goods strengthens U.S. national security by ensuring another nation cannot completely hold American supply chain needs hostage while providing the U.S. time and space through advanced manufacturing to circumvent any supply chain disruptions without harming national security.

Countering China's influence and progress from BRI manufacturing projects with advanced manufacturing technologies is well-aligned with the broader strategy to gain an asymmetric advantage to assist in retaining America's position as the global hegemon.

Annex B: Policy Development Methodology

The primary resource used to develop the national security policies in this research was A National Security Strategy Primer.⁶⁹ The research team applied the five fundamental elements of strategic logic (situation, ends, means, ways, and costs/risks) to produce policy recommendations. Analysis of the strategic environment is covered at length in the narrative. Also, the SWOT analysis flowed from the team’s assessment of the larger geopolitical situation and how advanced manufacturing could be leveraged to bolster the position of the U.S., its partners, and its Allies. Costs, risks, and gaps associated with each policy were identified, and the most relevant parts were captured in the narrative. Larger costs, risks, and gaps linked to the strategic situation were identified separately in the narrative. The four slides below illustrate the result of the team’s policy development that informed the proposed recommendations.

Policy to Bolster the American Workforce

Diagnosis that defines or explains the nature of the challenge	Guiding policy for dealing with the challenge		Coherent actions that are designed to carry out the guiding policy		Tangible costs or risks required to enact policy
Strength / Weakness / Threat / Opportunity	Interest	Policy Recommendation	Means	Ways	Costs, Risks, Gaps
<i>The issue / actor (internal or external) you are trying to influence – derived from your SWOT analysis</i>	<i>Start with the National Security Strategy; your SWOT analysis impacts your Interest</i>	<i>What you are trying to achieve. Policies address an issue from your SWOT analysis; Think Aspirational Idealism</i>	<i>Institutions using instruments of national power, supported by elements of national power DIME / PESTLE / STEEP / MIDFIELD</i>	<i>"How" you are trying to achieve your Policy Recommendation. Ways achieve specific objectives in pursuit of a political aim.</i>	<i>What will be needed or what can be repurposed to enable the ways/means. Can include natural resources, financial resources, manpower and/or time requirements. What risks are involved? Are there any gaps in the policy?</i>
The US manufacturing workforce is insufficient (unskilled and unfilled) to meet manufacturing needs	- Economic Prosperity and Opportunity - Secure the American people	Increase the American advanced manufacturing workforce to meet current industry workforce demands and mobilize in times of crisis.	Dept of Education and Dept of Commerce utilize information instruments of power to show the American public opportunities in advanced manufacturing	Manufacturing USA (Dept of Commerce) works with House Committee on Education & The Workforce and through Dept of Education to target 13-29 year old US citizens to enter careers in advanced manufacturing by: 1. DoE develop, ICW institutes, Cert programs and curriculum in MS - HS and CC 2. DoC (through America Makes) ICW DoE develops National Marketing Campaign focusing on target audience using generational appropriate means.	Uncommitted funds from the American Rescue Plan (1.62B) will be reallocated from unspent Educations funds to cover the costs of this policy

⁶⁹ Steven Heffington, Adam Oler, and David Tretler, eds. *A National Security Strategy Primer*. Washington, DC: National Defense University Press, 2021.

Policy to Establish Additive Manufacturing Standards

Diagnosis that defines or explains the nature of the challenge	Guiding policy for dealing with the challenge		Coherent actions that are designed to carry out the guiding policy		Tangible costs or risks required to enact policy
Strength / Weakness / Threat / Opportunity	Interest	Policy Recommendation	Means	Ways	Resources
<i>The issue / actor (internal or external) you are trying to influence – derived from your SWOT analysis</i>	<i>Start with the National Security Strategy; your SWOT analysis impacts your Interest</i>	<i>What you are trying to achieve. Policies address an issue from your SWOT analysis; Think Aspirational Idealism</i>	<i>Institutions using instruments of national power, supported by elements of national power DIME / PESTLE / STEEP / MIDFIELD</i>	<i>"How" you are trying to achieve your Policy Recommendation. Ways achieve specific objectives in pursuit of a political aim.</i>	<i>What will be needed or what can be repurposed to achieve policy. Can include natural resources, financial resources, manpower and/or time requirements.</i>
Persuade the American public and industry of the viability and reliability of advanced manufacturing processes and products. Ensure alignment with Allies and partners to ensure US lead for standards.	-Economic Prosperity (Increased adoption of AM) -Values (Protect US citizens w/standards)	Increase the comfort levels of US public and industry with AM products while leading the global adoption of AM standards.	The Department of Commerce inform the US public and industry on the benefits of AM. The Department of State to explain and advocate to Allies and partners to participate in standards adoption.	1. DoC with ASTM a common lexicon of terms that keeps pace with innovation 2. USG regulatory body that partners with ANSI to provide collaborative oversight on standards 3. State to advocate for key Allies and partners to participate in standards fora to promote commonality	- Risk of PRC leading global standards and exerting leverage counter to US interest. - Cost of companies changing from proprietary to common standards.

2

Ensure Access to Critical Goods

Diagnosis that defines or explains the nature of the challenge	Guiding policy for dealing with the challenge		Coherent actions that are designed to carry out the guiding policy		Tangible costs required to enact policy
Strength / Weakness / Threat / Opportunity	Interest	Policy Recommendation	Means	Ways	Resources
<i>The issue / actor (internal or external) you are trying to influence – derived from your SWOT analysis</i>	<i>Start with the National Security Strategy; your SWOT analysis impacts your Interest</i>	<i>What you are trying to achieve. Policies address an issue from your SWOT analysis; Think Aspirational Idealism</i>	<i>Institutions using instruments of national power, supported by elements of national power DIME / PESTLE / STEEP / MIDFIELD</i>	<i>"How" you are trying to achieve your Policy Recommendation. Ways achieve specific objectives in pursuit of a political aim.</i>	<i>What will be needed or what can be repurposed to achieve policy. Can include natural resources, financial resources, manpower and/or time requirements.</i>
The U.S. is heavily reliant on the global, yet vulnerable, supply chain to support its critical needs and would be unable to secure essential products during a disruption. Vulnerable supply chains and lack of access to critical goods as demonstrated during the COVID-19 pandemic	Defend Democracy and Expand Economic Prosperity by strengthening domestic manufacturing and ensuring access to critical goods	Incorporate advanced manufacturing technologies domestically and with Allies/ Partners to increased supply chain resilience, especially in <u>key areas which support critical and emerging technologies</u> that enable U.S. economic prosperity and national security.	Diplomatic: DOS engage with select international partners to establish areas of burden sharing and mitigate shared shortfalls in critical goods production. Information: The interagency collaboration between Departments of Defense, Health and Human Services, Energy, and Commerce, along with the Treasury Department and the House Committee on Ways and Means, to coordinate efforts in promoting additive manufacturing capabilities in small, lower-tier firms and sharing information on best practices and advancements in the field.	1. Incentivize small firms' additive manufacturing investments. 2. Facilitate interagency collaboration for promoting capabilities. 3. Engage international partners for burden sharing and collaboration. 4. Link small firms with key partners and Allies in various sectors. 5. Address stakeholders' hesitations with assurances and incentives.	Utilize the existing Supply Chain Resiliency Fund identified in the FY23 Presidential Budget to provide immediate access to approximately \$5 billion in incentives for small businesses to invest in additive manufacturing capabilities. Establish tax incentives for these firms in the long-term through coordinated legislation efforts.

3

Intellectual Property Sharing and Protection

Diagnosis that defines or explains the nature of the challenge	Guiding policy for dealing with the challenge		Coherent actions that are designed to carry out the guiding policy		Tangible costs required to enact policy
Strength / Weakness / Threat / Opportunity	Interest	Policy Recommendation	Means	Ways	Resources
<i>The issue / actor (internal or external) you are trying to influence – derived from your SWOT analysis</i>	<i>Start with the National Security Strategy; your SWOT analysis impacts your Interest</i>	<i>What you are trying to achieve. Policies address an issue from your SWOT analysis; Think Aspirational Idealism</i>	<i>Institutions using instruments of national power, supported by elements of national power DIME / PESTLE / STEEP / MIDFIELD</i>	<i>"How" you are trying to achieve your Policy Recommendation. Ways achieve specific objectives in pursuit of a political aim.</i>	<i>What will be needed or what can be repurposed to achieve policy. Can include natural resources, financial resources, manpower and/or time requirements.</i>
Small manufacturing firms could help expand US manufacturing footprint to meet current and surge demands but have limited access to large firms' intellectual property (IP) and are disincentivized to create their own IP due to the legal cost of enforcing patents	Promote economic prosperity and uphold US democratic values by supporting small manufacturers through IP protection and sharing incentives.	Develop a comprehensive framework for IP protection, establish standardized IP valuation and pricing methodologies, create tax incentives, and engage with international partners.	<ul style="list-style-type: none"> - Diplomatic: DOS Engage partners and allies to responsibly adopt American-developed IP in their advanced manufacturing sectors. - Information: DOC USPTO Create an interagency working group for IP protection and standardize IP valuation and pricing methodologies. - Economic: DOT and DOC utilize economic incentives and tax incentives to promote IP sharing between large and small manufacturing firms. 	<ol style="list-style-type: none"> 1. Develop a IP protection framework: The interagency working group led by the USPTO will create a policy framework to ensure IP protection in advanced manufacturing, addressing challenges faced by small firms. 2. Standardize IP valuation and pricing methodologies: Collaborate with industry stakeholders to establish transparent and fair methodologies, exploring innovative concepts such as leasing agreements for IP sharing. 3. Implement tax incentives: Work with Congress' Joint Committee on Taxation to develop and implement tax incentives that encourage large firms to share their IP with smaller ones, foster collaboration. 4. Promote American-developed IP internationally: The Department of State will engage with allies and partners, encouraging them to integrate American-developed IP in their advanced manufacturing industries while ensuring responsible IP protection. 5. Strengthen international legal frameworks for IP enforcement: Cooperate with international partners to establish robust legal frameworks that protect IP and promote responsible usage in advanced manufacturing industries. 	<ol style="list-style-type: none"> 1: Cost neutral but sets stage for other costs 2: Upfront R&D cost; could be offset with long-term cost savings

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