House Energy and Commerce Committee subcommittee meeting on:

AI in Manufacturing: Securing American Leadership in Manufacturing and the Next Generation of Technologies

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Professor of the Practice, MIT

February 12, 2025

Rebuilding the US industrial base using advanced manufacturing is an urgent priority for several reasons: supply chain resilience, geopolitical tensions, quality jobs, and advances in manufacturing technologies. The U.S. has made significant strides in the past few years to rebuild these capabilities with largely bipartisan support for investments in areas critical to the country's industrial base: semiconductors, critical minerals, defense and energy infrastructure. While the U.S. has made some important steps to expand manufacturing capabilities in critical areas to the country, there are some foundational challenges that must be addressed to succeed at rebuilding the U.S. industrial base. These fall into five primary areas:

1) ***Expand small and medium-sized enterprise (SME) technology adoption to increase productivity and wages***
2) ***Increase investment in manufacturing workforce training and education while building off existing successful programs***
3) ***Accelerate manufacturing innovation and scale-up***
4) ***Invest in the Research, Development and Deployment (R,D&D) of Advanced Manufacturing***
5) ***Limit the use of tariffs on products not critical to U.S. national security***

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Introduction

Good morning and thank you, Chairman Bilirakis, Ranking Member Schakowsky, Chairman Guthrie, Ranking Member Pallone, and Members of the Subcommittee. It is an honor to be with you this morning and speak about a topic that is of the utmost importance to the country's national and economic security.

Advanced manufacturing refers to a suite of manufacturing technologies as well as to production systems that are converging to create both new manufactured products and processes that can have a significant impact on U.S. innovation, growth and global competitiveness. These technologies involve digitalizing the production process through automation, AI, robotics, and additive manufacturing among other technologies to improve quality, yields, safety and overall productivity while also augmenting the capabilities and productivity of manufacturing workers.

Rebuilding the US industrial base using advanced manufacturing is an urgent priority for several reasons:

First, when I came to Washington in 2021 to work at the National Economic Council, the country was facing unprecedented supply chain disruptions and shortages due to the global pandemic. Our lack of resilience in critical supply chains for products and inputs as well as the lack of

transparency and connectivity across supply chains was apparent – whether it was low commodity Protective Personal Equipment (PPE) for our first responders, or high value-added semiconductors for our auto and medical device industries.

The emphasis on supply chain efficiency over resilience had left the country at a disadvantage, dependent on individual companies or countries for key inputs. Today, companies and countries have started to reconfigure their supply chains to address resilience which, in part, involves building domestic manufacturing capabilities.

Second, geopolitical tensions and increasing global competition have underscored the need for the U.S. to develop key technologies critical to national security and economic prosperity. Frontier technologies in areas such as biomanufacturing, quantum, critical materials production, defense and energy rely on advanced manufacturing capabilities. A strong defense industrial base as well as technological leadership in these key technologies depends upon the U.S.'s ability to innovate not just in design but also in production.

As MIT research[i] over the decades has underscored, manufacturing capabilities are deeply entwined with innovation capacity in both product and process innovation. It is through advances in manufacturing, including the use of AI, that we can increase the speed of production and time to market of new technologies, reduce costs, increase energy efficiency and provide quality jobs for workers.

Third, the loss of manufacturing jobs and the hollowing out of communities across the U.S. over several decades has had a devastating effect on people and places across the country.[ii] Manufacturing jobs represent a small share of US employment (under 10 percent[iii], although with a large multiplier effect), and new ones will be created at a slower rate, partly because of AI and automation. But these jobs are tied to technologies and industries that underpin the

country's national security and economic prosperity. Such work can provide solid career paths and be high quality in terms of wages and benefits, which is more important for the US than increasing the *quantity* of jobs[iv].

Finally, it is worth noting the significant technological advances being made in the industrial sector today. Industrial systems undergird the country – from transportation to energy to manufacturing – and with advances in process and product innovation, we can now manufacture differently than before, leading to completely novel production systems, whether making bioindustrial products or creating critical minerals like titanium and nickel or in novel 3D printing processes. Our challenge as a country is to scale and adopt these new technologies to give us a differentiated advantage in advanced manufacturing.

US Progress to Date

The U.S. has made significant strides in the past few years to rebuild these capabilities with largely bipartisan support for investments in areas critical to the country's industrial base: semiconductors, critical minerals, defense and energy infrastructure. The passage of the Bipartisan Infrastructure Law, the CHIPS and Science Act as well as the Inflation Reduction Act has led to several positive developments:

- Manufacturing construction spending has tripled since 2021[v]
- $450 billion of private sector investment in semiconductor production across over 40 facilities will reduce US reliance on any one company or region for advanced semiconductor production.[vi]

- Approximately $80 billion of private sector has been invested to date on clean energy-related production across over 200 manufacturing facilities, primarily in battery production, a crucial area for US global leadership in the future [vii].
    - These investments, facilitated by tax incentives, will be essential to ensuring energy security for the country at a time when the rise of AI will only increase energy demand. Energy demand in the state of Virginia, for example, is expected, to double in just a decade.
    - Investments are going to a range of states: for example, over $5 billion is being invested in each of the following states: Georgia, Michigan, Tennessee, North Carolina and Ohio
- The leverage of these public dollars is significant: roughly $4-7 private dollars invested for every federal dollar spent.

In addition to these strategic investments, significant investments have been made in the defense industrial base in key areas such as microelectronics, bioindustrials and critical minerals, as well as new sources of funds for startups and suppliers in the aerospace and defense supply chain.[viii]

Recommendations

While the U.S. has made some important steps to expand manufacturing capabilities in critical areas to the country, there are some foundational challenges that must be addressed to succeed at rebuilding the U.S. industrial base. These fall into five primary areas:

1) ***Expand small and medium-sized enterprise (SME) technology adoption to increase productivity and wages***

Despite the return on investment associated with digital technology adoption by SMEs, many are reluctant to invest because they are risk-adverse and hesitant to change existing manufacturing processes. There are 250,000 small and medium-size manufacturers in the country. If we wanted as a country to ensure that just 20% of them were at the frontier of digitalization and ready for 21st manufacturing, that would be 50,000 manufacturers. Currently, we do not have a way to reach these companies at scale. Financial incentives are required to help those SMEs that are interested in growing to make the leap into digital manufacturing. Several steps could be taken:

- Provide federal matching funds to state-led programs that offer incentives to SMEs with a growth mindset willing to invest in new productivity-enhancing technologies that include hardware, software and integration services. There are several successful programs at the state level such as the Indiana Manufacturing Readiness Grant, the Massachusetts Manufacturing Accelerate Program and the Michigan Industry 4.0 Technology Implementation Grants.

- Large manufacturers that have contracts with, or grants from the federal government should be incented to support digitalization among their suppliers. Provide carrots to OEMs that can show that all tiers in their supply chain are digitally enabled and that they are supporting their SMEs in digital transformation.

- Create a national, AI-based open-source platform of advanced digitalization tools to encourage manufacturers to adopt digital technologies in their operations. Leverage the Manufacturing USA network, specifically the soon-to-be announced AI and Manufacturing Innovation Institute[ix] to elevate AI adoption among SMEs as a national priority.

- Modernize the Manufacturing Extension Program's work with SMEs so they are focused on "augmented lean"[x], promoting lean principles while also supporting digitalization. MEPs need to reinterpret their role to include helping SMEs navigate a complex and dynamic technology market in which digital technology is now a prerequisite for competitive manufacturing performance. This may require creating a new set of metrics by which MEPs are measured.

2) Increase investment in manufacturing workforce training and education while building off existing successful programs

Revitalizing and expanding the manufacturing workforce is critical to the U.S. economic and competitiveness agenda going forward. It is estimated the US could face a shortage of nearly two million manufacturing workers[xi] by 2033. The best way to avert a shortfall is to upskill current workers, which would make them more productive and extend their careers, as well as attract a new generation into the sector through use of advanced technologies. This can be achieved alongside digitalization, because companies that adopt new and advanced technologies also invest in skills upgrading[xii] of their workforce.

AI can play a positive role in this process by augmenting the skills of frontline manufacturing workers by reducing routine activities and democratizing the technology so workers are part of "continuous improvement". This process can lead to improving manufacturing wages, which today, on average, are less than the average all-industry hourly wage for non supervisory workers.[xiii]

Several steps can be taken to upskill and expand the US manufacturing workforce:

- Create robust pre-apprenticeships and apprenticeship programs for manufacturing education that can be adapted from the Swiss and German models. Connect apprenticeship programs across industry and community colleges[xiv] and learn from existing state-wide programs.[xv]
- Identify the most successful manufacturing training programs in the country and look to scale them. The Department of Defense as well as a number of Manufacturing USA institutes[xvi] and community colleges have strong manufacturing training programs that could be scaled.
    - Bring advanced manufacturing into undergraduate engineering curricula.[xvii]
    - Combine online education with learning-by-doing to scale advanced manufacturing workforce education.
- Encourage four-year institutions of higher education to partner with community colleges, industry and state and local government to develop workforce programs, including for a new manufacturing position and career path between technician and engineer.[xviii]
- Diversify the workforce including targeting an increase in the number of women working in manufacturing. Currently, women represent approximately 30 percent of the US manufacturing workforce but that number could be increased with greater flexibility and increased pay.

3) Accelerate manufacturing innovation and scale-up

The U.S. is the envy of the world and is renowned as the “startup nation.” But it now has to become the “scale up nation.” Decades of capital markets focused on “asset light” investments have made it difficult for manufacturing startups to find growth capital to meet their large capital needs over longer time horizons than pure software investments.

New financing models, tools and instruments are needed to address the “missing middle” capital gaps needed by startups to scale advanced manufacturing technologies from pilot to demonstration-at-scale[xix]. Challenges exist across multiple industries including semiconductors, biomanufacturing, clean energy and advanced manufacturing technologies. Several steps could be taken:

- Use federal procurement to support commercialization of novel technologies. Early-stage technologies struggle to secure customers because prices for their first few units may be too high, or customers may not be willing to commit until they have actually seen the products work. Many technology innovations and breakthroughs have come through the use of government procurement tools, particularly from the DOD. Such tools, like advanced market commitments that guarantee purchase of a product or “offtake” have also been used beyond defense, such as vaccine production. The federal government could increase its impact in priority areas by using procurement tools to accelerate innovation, technology adoption and scale up in areas such as biomanufacturing, defense including drone production and shipbuilding, and energy security including geothermal and nuclear energy.

- Explore new scale-up financing tools that could help scale production that requires a longer time horizon and increased capital expenditures for pilot and demonstration-at-scale production. Currently, U.S. capital markets, specifically venture capital, are not well aligned with the long-term investments required to bring manufacturing/engineering - based startups to scale given the amount of equity an investor must take early on to reach desirable returns. The federal government could:

    - Provide tax incentives for startups that are building their first manufacturing facility in the U.S.
    - Engage the private sector in exploring new financing models such as a "First-of-a-Kind" (FOAK) fund and "tech insurance" in which credit insurance is developed for customers and lenders to cover performance risk on projects where others are unlikely to appropriately price technology risk.
    - Explore the role for a federal Industrial Finance Corporation[xx] that could operate like the Development Finance Corporation (DFC) to help companies with financing of FOAK and early stage scale up.
- Expand the role of Manufacturing USA Institutes to allow for engagement at the pilot production stage of manufacturing scale up. The Institutes' initial mandate was to focus on Manufacturing Readiness Levels (MRLs) 4-7, between lab to pilot production. The Institutes should be leaning into pilot production and low-rate initial production (LRIP) to extend their MRL work to 8/9 to help de-risk technologies further to attract private sector investment.

4) Invest in the Research, Development and Deployment (R,D&D) of Advanced Manufacturing

Historically, U.S. federal R&D institutions have underinvested in advanced manufacturing processes. Additional R, D and D funding is required in emerging advanced manufacturing technologies to help the U.S. stay ahead in such areas as biomanufacturing, quantum, semiconductors, energy and critical minerals. Through investments in science and engineering breakthroughs, the US can dramatically increase yields, reduce costs and strengthen supply chain resilience while “leapfrogging” current standard manufacturing processes.

5) Limit the use of tariffs on products not critical to U.S. national security or fair trade

Tariffs can be used effectively if used in limited and targeted ways to protect national security as well as address unfair trade practices. However, used broadly, and particularly against trading partners and allies with whom U.S. manufacturers rely heavily, will have long-term negative effects on US manufacturers and consumers.

The current uncertainty introduced by the Trump administration by the imposition and pausing of tariffs on US allies and largest trading partners Mexico and Canada, are creating costly disruptions to manufacturers in the US. Tariffs may help domestic manufacturers by protecting them from foreign competition, but they hurt them and other industries by driving up the cost of imported components. The auto industry, for example, is particularly at risk with such policies. No cars currently manufactured in the U.S. are built without imports from Mexico and Canada. Without incentives to increase competitiveness, tariffs can also lead to uncompetitive companies unwilling to invest in innovation. Ultimately, tariffs also drive up consumer prices.

Conclusion

Thank you for the opportunity to speak with the Committee today. I hope my remarks have underscored the importance of the U.S. manufacturing agenda to the country and the urgency with which we must address the opportunities and challenges for the U.S. industrial base.

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[iii] Bureau of Labor Statistics, https://data.bls.gov/timeseries/CES3000000001
[iv] Autor, D., Mindell, D. and Reynolds, E. (2022). *The Work of the Future: Building Better Jobs in the Age of Intelligent Machines*, MIT Press.
[v] See FRED Total Construction Spending in Manufacturing, https://fred.stlouisfed.org/series/TLMFGCONS
[vi] The Economist, "America's Bet on Semiconductors Starts to Pay Off," January 9, 2025. https://www.economist.com/united-states/2025/01/09/americas-bet-on-industrial-policy-starts-to-pay-off-for-semiconductors
[vii] Rhodium/MIT CEEPR, Clean Energy Investment Monitor, Q3 2024 update; https://www.cleaninvestmentmonitor.org/reports/clean-investment-monitor-q3-2024-update
[viii] See multiple announcements related to the DIB including the Microelectronics Commons: https://www.cto.mil/ct/microelectronics/commons/; the Bioindustrial Manufacturing Program: https://www.defense.gov/News/Releases/Release/Article/3662704/dod-launches-distributed-bioindustrial-manufacturing-program-to-bolster-domesti/; DPAP awards for Critical Minerals Production: https://www.acq.osd.mil/news/office-news/asda/2024/Summary-of-DPAP-Awards-Funded-via-Inflation-Reduction-Act.html , and new investment vehicles such as the DOD Office of Strategic Capital as well as the new SBIC created with DOD, "ASTRO America's AM Forward Initiative Gets Final Approval for Private Equity Fund, https://astroa.org/press-release-astro-america-lauds-governments-approval-of-new-private-equity-fund/
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[xi] Deloitte, "US Manufacturing Could Need as Many as 3.8 million New Employees by 2033," April 3, 2024; https://www2.deloitte.com/us/en/pages/about-deloitte/articles/press-releases/us-manufacturing-could-need-new-employees-by-2033.html
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[xv] See Bonvillian, W. and Sarma, S, (2021). *Workforce Education: A New Roadmap*, MIT Press. For good examples of apprenticeship programs, see Indiana Modern Apprenticeship Program as well Apprenticeship Carolina of the South Carolina Technical College System.
[xvi] Bonvillian, W. (2022). The Playbook for Workforce Education at Manufacturing Innovation Institutes, ResearchGate; https://www.researchgate.net/publication/366893743_The_Playbook_-_for_Workforce_Education_at_Manufacturing_Innovation_Institutes

[xvii] See the National Academies report (2022). “Infusing Advanced Manufacturing into Undergraduate Engineering Education,” https://nap.nationalacademies.org/catalog/26773/infusing-advanced-manufacturing-into-undergraduate-engineering-education

[xviii] Liu,J and Bonvillian, W (2024). “The Technologist,” in *Issues in Science and Technology*, Winter, 2024. https://issues.org/technologist-advanced-manufacturing-workforce-liu-bonvillian/

[xix] For an overview of the challenge as it relates to the clean energy industry, see SG2 Ventures, “The Missing Middle: Capital Imbalances in the Energy Transition,” September, 2023. Earlier research at MIT highlighted the challenge across a number of technology areas: Reynolds, E., H. Samel and J. Lawrence (2014). “Learning by Building: Complementary Assets and the Migration of Capabilities in U.S. Innovative Firms,” in *Production in the Innovation Economy*, Eds Richard Locke and Rachel Wellhausen, Cambridge, MA: MIT Press, pp 81-107.

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