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THE STRATEGIC IMPLICATIONS OF INDUSTRY 4.0
IN GREAT POWER COMPETITION

Advanced Manufacturing: ES 6712

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Acknowledgments

As the nation cautiously emerges from fifteen months of quarantine and isolation necessary to minimize damage from the COVID-19 pandemic, it is easy to focus on what was lost. Over three million lives and economic damage valued in the trillions of dollars rival the impact of the Great Depression on worldwide economic growth. The pandemic significantly affected the academic year, sharply limiting opportunities for social interaction and professional networking. The pandemic eliminated international travel necessary to meet with and observe the best practices of our foreign allies and partners. Our seminar interaction with the leaders of the American industry suffered sharply reduced opportunities. Still, there have been blessings amid the losses, and many people have contributed to make the academic year a success.

First, we would like to thank all the faculty and staff at the Eisenhower School for their efforts to deliver a rich, fulfilling virtual learning experience. Notably, we would like to thank Colonel Kenneth “K.C.” Bradford, Professor Todd McAllister, Colonel Todd Miller, and Professor Noah Myung for their role in shaping our understanding of the economic and political forces influencing U.S. manufacturing.

We appreciate the government, academic, and industry representatives who met with us this semester, usually from their own home offices, also buzzing with the background sounds of children, pets, and spouses. Your expertise and insights were invaluable in developing the policy recommendations contained in this paper. By giving voice to your wisdom, we hope to help the nation better realize its enduring goals of safeguarding liberty and providing economic prosperity for the American people.

Most importantly, we would like to thank our families not only for sharing their bandwidth with us but for their unwavering love, patience, and support throughout the year.

-Seminar 14 “Not Those Guys”

Executive Summary

The tools and techniques of the Fourth Industrial Revolution, or Industry 4.0, create strategic opportunities for the nations and firms best able to leverage the incredible increase in systems connectivity and data. This paper summarizes five months of research and discussions with Industry, Government, and Academia on the advanced manufacturing technologies made possible by Industry 4.0. We compare and assess competing for national industrial systems and policies and evaluate divergent firm and market strategies. Our team paid attention to the manufacturing ecosystems in the United States, the People’s Republic of China (PRC), and the Russian Federation, using the Porter’s Diamond Model of National Advantage to identify each nation’s unique strengths, weaknesses, opportunities, and threats. This analysis proposed policy recommendations to strengthen the U.S. manufacturing base and expand and diversify the nation’s supply chain for Great Power Competition.

Strategic competition among the “Great Powers” finds the U.S. and PRC, the world’s two largest economies and manufacturers, in a contested rivalry for global diplomatic, military, and economic influence. In the early months of 2021, both nations released a financial plan that explicitly emphasizes digital transformation and the tenets of Industry 4.0. Each country promises government funding and other support for its industries. The methods differ only in the size of the government subsidies and mechanisms of reinforcement between the countries. In contrast to the U.S. and PRC, Russia, while it remains a military power, lacks the economic clout to sustainably project power at great distances beyond its borders. The effects of long-running economic sanctions have resulted in limited foreign investment and slow economic growth. Russia’s modest plan for digital transformation is underfunded and behind schedule and is not likely to be realized soon. For this reason, the analytical effort focused primarily on the contest between the U.S. and PRC.

Assessing the U.S. industrial system, we found signs of a robust innovation sector with first-rate academic research institutions, easy access to capital, and strong intellectual property laws. However, the U.S. lacks a consistent and coordinated industrial policy, has grown dependent on foreign resources and suppliers, has scaled-back support for research and development, and has found signs of weakness in the primary and secondary education systems. The PRC has some similarities and differences from the U.S. The PRC industrial system benefits from a well-executed central plan, abundant domestic suppliers, loose regulation, abundant labor, and large government subsidies to support innovation and manufacturing. However, after decades of rapid growth, there are signs of a slowdown. The PRC system could benefit from market liberalization to increase the number of domestic competitors. Also, the authoritarian government’s pattern of aggression, debt-trap diplomacy, and human rights abuses has left some nations reluctant to expand their partnerships with the PRC, perhaps limiting their market penetration in these countries. The U.S. can assert policies to address China’s aggression.

Our team developed policy recommendations to advance U.S. interests and minimize the threat of PRC hegemony in advanced manufacturing and high-value industries after considering the differences in capabilities between these competing industrial systems. The U.S. must execute the following five critical policies that support a manufacturing renaissance in high-value industries:

- **Promote U.S. International Standards for Advanced Manufacturing**
- **Develop and Strengthen International Advanced Manufacturing Partnerships**

- **Provide High-Performance Computing Resources to Enable Data-Driven Manufacturing**
- **Subsidize U.S. Research and Development and Capital Investment through Tax Policy**
- **Provide Career and Technical Education for a 21st Century Workforce**

These recommendations form the foundation of an integrated economic and industrial strategy that balances technological innovation with high-value production output. While there are substantial risks to consider when applying these policies, America's national security is at greater risk if it does not outpace its rivals' production capacities.

INTRODUCTION

The 2017 National Security Strategy describes domestic manufacturing as a vital link to supply chain security and a resilient defense industrial base.¹ The U.S. government must adopt new policies encouraging firms in high-value industries to adopt the tools of advanced manufacturing and industry 4.0. to support national security objectives and reinvigorate the American manufacturing base. The new policies will help secure critical supply chains, contribute to GDP growth, and better position the U.S. for Great Power Competition. The United States' market economy and highly innovative manufacturing sector position it well to compete in the 21st-century global economy. However, competitors have gained an increasing percentage of manufacturing market share due to their lower labor costs, higher levels of government support, increasingly effective workforce education, and concentration of raw materials, and presence of related and supporting industries. These elements combine to create national economic strength.

The economic and military might of nations inextricably links the strength and capability of their manufacturing sector since the birth of the Industrial Revolution. The U.S. emerged as a superpower through its manufacturing might, serving as the “Arsenal of Democracy” during World War II. America provided such abundant material for the Allied war effort that Germany was overwhelmed.² After the war, the United States transitioned its newfound manufacturing efficiency to peacetime production and dominated the world's commercial markets for fifty years. Economists and historians observed that industrialization gave rise to higher education levels, longer life spans, growing individual and national income, and improved overall quality of life. The continuation of these trends will depend on the nation's ability to master the tools of the Fourth Industrial Revolution, or Industry 4.0, and the cyber-physical systems as our countries compete across the global landscape.

Preparing the nation for Great Power Competition, an interagency Cabinet Secretary team assessed the capacity and resilience of the Defense Industrial Base (DIB) and its supply chains.³ The team identified five macro forces negatively affecting the DIB: uncertainty in government spending, the decline of U.S. manufacturing, inefficient government procurement practices, the harmful industrial policies of competitor nations, and the critical skills of U.S. manufacturing workers.⁴ In its 2020 assessment of the DIB, DoD noted the “deindustrialization trend” of the past fifty years. It warned that a declining manufacturing sector risks “a growing and likely permanent national security deficit” and was concerned that manufacturing now accounts for less

¹“NSS-Final-12-18-2017-0905-2.Pdf.” n.d. Accessed April 5, 2021.

<https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905-2.pdf>.

² Roosevelt, F. D. Fireside Chat radio broadcast. December 1940.

³ Donald Trump, “Executive Order 13806: Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States,” The American Presidency Project, accessed April 4th, 2021,

<https://www.presidency.ucsb.edu/documents/executive-order-13806-assessing-and-strengthening-the-manufacturing-and-defense-industrial>

⁴ Ibid.

than 12 percent of the economy.⁵ Strong strategic policies are necessary to support a manufacturing rebound.

This paper identifies and recommends policies that would support a U.S. manufacturing renaissance and rebuild the industrial commons to support high-value industries using the tools of Industry 4.0. The lenses of Great Power Competition and the Porter Diamond Theory of National Advantage compare the United States, the PRC, and the Russian Federation's competitive advantages to determine which U.S. government policies could best prepare the DoD and the nation for the competitive environment. Advanced manufacturing has always driven the research, design, and development of new technologies, with applications for national defense. And advanced manufacturing has always depended on a highly skilled workforce to increase productivity and innovation.⁶ U.S. national security is at risk if our manufacturers do not embrace the principles of the Fourth Industrial Revolution and outpace our rivals' innovation and production capabilities. Winning this century's Great Power Competition will depend on our ability to lead the world in advanced manufacturing, just as it did in earlier times.

STRATEGIC ENVIRONMENT

After being dismissed as a phenomenon of an earlier century, great power competition returned. China and Russia began to reassert their influence regionally and globally. Today, they are fielding military capabilities designed to deny America access in times of crisis and to contest our ability to operate freely in critical commercial zones during peacetime. In short, they are contesting our geopolitical advantages and trying to change the international order in their favor.⁷

- National Security Strategy of the United States of America, December 2017

While many nations might make a case for contemporary great power status, the framework guides the analysis created by the 2017 National Security Strategy, which found that the U.S., the PRC, and Russia were engaged in a contest for worldwide influence and leadership. The strategic environment is considered in each of these nations related to advanced manufacturing and Industry 4.0.

United States

While in office for just over 100 days at the time of this writing, President Biden has already provided sufficient guidance for the authors to project how his administration will shape the strategic environment in the coming years. He has issued an Interim National Security

⁵ "Fiscal Year 2020 Industrial Capabilities Report to Congress," OSD A&S Industrial Policy, January 2021, <https://media.defense.gov/2021/Jan/14/2002565311/-1/-1/0/FY20-INDU.S.TRIAL-CAPABILITIES-REPORT.PDF/>.

⁶ "The Strategy for American Leadership in Advanced Manufacturing," Subcommittee on Advanced Manufacturing, Committee on Technology of the National Science and Technology Council, October 2018, <https://trumpwhitehouse.archives.gov/wp-content/uploads/2018/10/Advanced-Manufacturing-Strategic-Plan-2018.pdf>

⁷ National Security Strategy of the United States of America. December 2017.

Strategic (NSS) Guidance, signed an Executive Order “Ensuring the Future Is Made in All of America by All of America’s Workers,” and unveiled the \$2.6 trillion “American Jobs Plan (AJP).” While not finalized or law, the latter is indicative of Congress’ and the administration’s priorities. With narrow Democratic majorities in Congress, enough of the proposed plan may survive committee to inform discussion of manufacturing policy development. Of specific interest, the Interim NSS includes international economic disruptions as one of the nation’s biggest threats. It identifies the PRC as the only rival “capable of combining its economic, diplomatic, military, and technological power to mount a sustained challenge to a stable and open international system.” Additionally, the Interim NSS calls for “investments to encourage innovation, strengthen national competitiveness, produce good-paying jobs, [and] rebuild American supply chains for critical goods.”⁸

The executive order is the first step to implement the interim strategy. It immediately redirects \$600 billion in government spending by increasing the threshold and price preferences for U.S. manufactured goods and using the nationwide Manufacturing Extension Partnership program to link small and mid-sized manufacturers to the federal government to identify domestic sources of supply better.⁹ The AJP would provide an additional \$300 billion to boost U.S. manufacturing as the nation recovers from a health and economic crisis. The AJP proposes \$50 billion to rebuild domestic semiconductor production capacity; \$50 billion to ensure the domestic production of critical goods; \$46 billion to accelerate domestic clean energy manufacturing (advanced nuclear reactors and fuel, electric vehicles and infrastructure, and electric heat pumps); and \$30 billion to domestic manufacturing for pandemic and medical preparedness. The Plan would increase manufacturers’ access to capital with a \$52 billion fund, with an additional \$31 billion targeted for small businesses, send \$20 billion to innovation hubs, and \$14 billion to the National Institute for Science and Technology (NIST).¹⁰ These efforts build on an existing patchwork of manufacturing and innovation programs surviving from the Obama and Trump administrations, indicating some level of enduring bi-partisan support for subsidizing domestic manufacturing. Bi-partisan support is essential in providing U.S. businesses with the continuity needed to justify multi-year investments in Industry 4.0 and advanced manufacturing capabilities. Some entities perceive the lack of U.S. business continuity as advantageous for the one-party PRC state.

People’s Republic of China

Released in parallel with the U.S. effort on March 11, 2021, and with similar intent, the PRC’s National People’s Congress completed the 14th Five Year Plan (2021-2025), defining the nation’s high-level social and economic and goals.¹¹ Specific to manufacturing, the Plan speaks

⁸ United States of America. Interim National Security Strategy. March 2021.

⁹ The White House. “Executive Order on Ensuring the Future Is Made in All of America by All of America’s Workers,” January 25, 2021. <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/25/executive-order-on-ensuring-the-future-is-made-in-all-of-america-by-all-of-americas-workers/>.

¹⁰ The White House. “FACT SHEET: The American Jobs Plan,” March 31, 2021. <https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/31/fact-sheet-the-american-jobs-plan/>.

¹¹ “The 14th Five-Year Plan for National Economic and Social Development of the People’s

of the need to accelerate and deeply integrate advanced manufacturing and to “build a modern industrial system with coordinated development of the real economy, scientific and technical innovation, modern finance and human resources.”¹² The plan overlaps extensively with U.S. manufacturing initiatives, emphasizing intelligent and green manufacturing, transitions legacy industries, seeks to diversify and secure the industrial supply chain, promotes small and mid-sized businesses, and creates national manufacturing innovation centers and a national intelligent manufacturing demonstration facility. Targeted industries include integrated circuits, aerospace, and space, marine and deep-sea, medicine and genetics, robotics, advanced rail, electric vehicles, refined power and hydrogen fuels, artificial intelligence, and high-end machine tools. Of more concern is an indication that the PRC will continue to subsidize the development of manufacturing “small giant” businesses and “national champions.” Since 2001, when the PRC entered the World Trade Organization (WTO), it has consistently subsidized 20 percent of its manufacturing industries’ costs, allowing Chinese manufacturers to gain an absolute advantage over their overseas rivals.¹³ In the United States and many other nations, this has resulted in the loss of entire industries, with the associated loss of jobs and national wealth. However, it appears that the world has awakened to this threat: new European Union regulations prevent subsidized foreign firms from winning public contracts or acquiring European businesses, and the United States has been iteratively upgrading its rules on foreign investment and acquisitions since the start of the U.S.-China trade war in 2018.¹⁴ In contrast to China, the Russian economy is on a different trajectory.

Russian Federation

The Russian Federation has not released national economic guidance since its 2017 Digital Economy, designed to direct the nation until 2024. This more modest plan provides \$10.5 billion to finance regulatory bodies, education and personnel, cybersecurity and research initiatives, and information technology infrastructure, especially Fifth Generation (5G) telecommunication and space-based communication and navigation systems.¹⁵ By 2020, even before the COVID-19 pandemic, these initiatives were behind schedule and underfunded.¹⁶ Then-Prime Minister Dmitri Medvedev foresaw these difficulties as early as 2018, citing

Republic of China and the Outline of Vision Goals for 2035.” Accessed May 5, 2021. http://www.gov.cn/xinwen/2021-03/13/content_5592681.htm.

¹² Ibid.

¹³ Ezell, Stephen. “China-Induced Global Overcapacity an Increasing Threat to High-Tech Industries.” Information Technology and Innovation Foundation, February 27, 2018. <https://itif.org/publications/2018/02/27/china-induced-global-overcapacity-increasing-threat-high-tech-industries>.

¹⁴ South China Morning Post. “EU Moves to Curtail Subsidised Firms in Veiled Swipe at China,” May 5, 2021. <https://www.scmp.com/news/china/diplomacy/article/3132394/eu-moves-curtail-subsidised-firms-veiled-swipe-china>.

¹⁵ Briefing, Russia. “Russia Moves to Fund Digital Economy in Five Sectors.” Russia Briefing News, April 2, 2018. <https://www.russia-briefing.com/news/russia-moves-fund-digital-economy-five-sectors.html/>.

¹⁶ “Russia’s National Program for Digital Economy Stumbles,” September 4, 2020. <https://www.intellinews.com/russia-s-national-program-for-digital-economy-stumbles-188718/>.

concerns about a shrinking workforce, slowing growth, and the harmful effects of international sanctions.¹⁷ Recent Russian provocations, including the murder of political opposition, foreign election interference, and military actions in Crimea, have resulted in sanctions and made it more difficult for Russia to attract the foreign investment necessary to accomplish its digital transformation. Indeed, without outside funding, the goals of the change may be unattainable. Indicative of Russia's future, the Sputnik V COVID-19 vaccine developed by the Russian scientific and innovation system could not accelerate its production. Russia partnered with four Chinese firms to produce the vaccine at scale.¹⁸

STRATEGY AND STAKEHOLDER INTERESTS

In his book, *Good Strategy/Bad Strategy: Why it Matters*, Richard Rumelt distills to its essence the process of strategic thinking and action. Strategists begin with diagnosing the core challenges facing their organizations. They incorporate a sound policy explicitly designed to overcome their challenges. Finally, these strategists execute well-reasoned and coordinated actions that advance the policies they seek. We can apply Rumelt's framework to U.S. advanced manufacturing and national defense.

In its FY20 assessment of the defense industrial base, the DoD warned that a declining manufacturing sector risks "a growing and likely permanent national security deficit."¹⁹ Advanced manufacturing drives research, design, and development of new technologies, many of which have applications for national defense. High tech manufacturing also depends on a highly skilled workforce that in turn generates increased productivity and innovation.²⁰ U.S. national security is at risk if U.S. advanced manufacturing does not outpace our rivals' productive capacities. A thriving advanced manufacturing sector has direct implications for defense acquisition. Technology Readiness Levels (TRLs) and Manufacturing Readiness Levels (MRL) define when innovations are prepared and cost-effective for production and use by warfighters. Advanced manufacturing helps accelerate the timetable for manufacturing readiness. It can narrow the "innovation gap" between proof of concept and production. World-beating manufacturing technology and production skills can help the United States be first with advanced

¹⁷ Roscongress Bulding Trust. "Putting Russian Economy on a Sustained Path of Growth: Challenges and Solutions." Accessed May 7, 2021. <https://roscongress.org/en/sessions/rossiyskaya-ekonomika-na-traektorii-rosta-vyzovy-i-resheniya/discussion/>.

¹⁸ Roscongress Bulding Trust. "Putting Russian Economy on a Sustained Path of Growth: Challenges and Solutions." Accessed May 7, 2021. <https://roscongress.org/en/sessions/rossiyskaya-ekonomika-na-traektorii-rosta-vyzovy-i-resheniya/discussion/>.

¹⁹ "Fiscal Year 2020 Industrial Capabilities Report to Congress," OSD A&S Industrial Policy, January 2021, <https://media.defense.gov/2021/Jan/14/2002565311/-1/-1/0/FY20-INDU.S.TRIAL-CAPABILITIES-REPORT.PDF/>.

²⁰ "The Strategy for American Leadership in Advanced Manufacturing," Subcommittee on Advanced Manufacturing, Committee on Technology of the National Science and Technology Council, October 201, <https://trumpwhitehouse.archives.gov/wp-content/uploads/2018/10/Advanced-Manufacturing-Strategic-Plan-2018.pdf>

equipment in the field. This first-mover advantage helps deter or defeat our enemies. Rumelt's strategic framework is not complete without sound policy and concrete actions designed to overcome the challenge. To ensure America's dominance over our GPC rivals in 21st-century defense production, the United States should enact procedures to secure its global leadership of advanced manufacturing, incent companies to innovate and invest in advanced manufacturing, and develop its manufacturing workforce. In October 2018, the National Science and Technology Council issued a revised *Strategy for American Leadership in Advanced Manufacturing*. The Strategy is laudable but has some shortcomings. Some of its policy prescriptions lack details, such as ways and means or defined actions to achieve policy goals. Also, its policies are domestically focused. The United States can improve advanced manufacturing by cooperating with partners. Likewise, we can take steps with our international partners to enhance the strategic environment of U.S. advanced manufacturing.

The U.S. should pursue concrete actions that bolster or preserve advanced manufacturing's strategic advantages or mitigate the root causes of advanced manufacturing's weaknesses. These include coordinated diplomatic and industry measures to set international standards for fast-evolving technologies and build international manufacturing partnerships. The United States should consider implementing fiscal incentives that encourage R&D and the adoption of advanced manufacturing technology. Policies that extend and protect the sharing and processing of research and manufacturing information will be essential. Finally, the United States must restore the image and funding to career and technical education (CTE), a backbone of advanced manufacturing. The stakes are high, and there are myriad stakeholders. Preserving the United States' leadership in advanced manufacturing requires the type of public-private cooperation at which the United States excels. For example, the Department of State and the U.S.AID manage global engagement on international standards and economic cooperation. The Department of Commerce, Department of Energy, Department of Defense, and the National Science Foundation sponsor research at their National Laboratories, Manufacturing Extension Partnerships, Manufacturing Institutes, and universities. The Department of Education and the Department of Labor work with state and local governments, academia, and companies to administer workforce development. When industry, government, and academia work in concert, the American people benefit. Porter's Diamond Analysis of the United States and our great power competitors, China and Russia, help develop a better understanding of the American benefit.

PORTER'S DIAMOND MODEL ANALYSIS OF NATIONAL ADVANTAGE

One lens commonly used to evaluate nations' competitive advantages is Porter's Diamond Model, depicted in Appendix-1, Figure 1.²¹ Porter believes that governments should proactively "act as catalyst and challenger" to help their industries gain competitive advantage but should not be directly involved in the industry.²² Porter's work, written in 1990, predates the rise of the PRC and does not seem to describe the market distortions created by a government

²¹ Drey, Eric. "Can Automation Restore U.S. Competitiveness in the Shipbuilding Industry?" National Defense University. February 2021.

²² Porter, Michael. "The Competitive Advantage of Nations." Harvard Business Review. March-April 1990.

subsidizing absolute advantage in an industry.²³ However, because of its pervasiveness, this Porter's Diamond analysis helps to evaluate the competitiveness of the advanced manufacturing industry.²⁴ The firm strategy, structure, and rivalry and important competitive indicators.

Firm Strategy, Structure, and Rivalry - United States

U.S. manufacturers are non-state controlled, private, or public companies. Firm structure, ownership, and size vary widely, from large multinational corporations to smaller sole proprietorships. According to the U.S. census, in 2015, 96% of all U.S. manufacturing exporters were Small and Medium Enterprises (SMEs) employing fewer than 500 workers.²⁵ This broad base of small, diverse companies encourages both competition and innovation. Rather than serving whole markets, these smaller firms focus their strategies on smaller, niche customers with unique needs. While they are excellent innovators, smaller firms have limited ability to raise capital for expensive new equipment and programs compared to large C Corporations. As illustrated by the COVID-19 pandemic, SMEs also maintain lower working capital accounts, making them more vulnerable to demand fluctuations and supply chain disruptions.²⁶ Many SMEs cannot overcome unpredictable demand cycles and invest in the tools necessary to adopt advanced manufacturing, absent government assistance.

Firm Strategy, Structure, and Rivalry - China

After ascending to power in 1949, the Chinese Communist Party (CCP) implemented a nationalization policy, bringing all manufacturing firms under state control. These State-Owned Enterprises (SOEs) proved highly inefficient. Chinese State-Owned Enterprises (SOEs) makeup 40% of all Chinese firms but achieve only a 3.9% Return on Assets (ROA) compared to 9.9% for their privately-owned counterparts.²⁷ Recognizing the benefit of private ownership, the Chinese Communist Party (CCP) privatized many manufacturing SOEs starting in the 1970s. However, the legacy of state ownership still adversely impacts China's innovative culture. Moreover, the state still directly controls many related and supporting industries, like energy and raw materials.²⁸ The supporting and related industries are directly tied to the SOEs, unlike a free-market economy.

²³ Drey, Eric. "Can Automation Restore U.S. Competitiveness in the Shipbuilding Industry?" National Defense University. February 2021.

²⁴ Ibid.

²⁵ "Facts & Data on Small Business and Entrepreneurship." *Small Business and Entrepreneurship Council*. Accessed 13 May 2021. <https://sbecouncil.org/about-us/facts-and-data/#:~:text=Among%20all%20U.S.%20manufacturers%3A%20%E2%80%9C96.4,sector's%20%24798%20billion%20in%20exports.>

²⁶ "OECD Policy Responses to Coronavirus (COVID-19)." 2020. *Organisation for Economic Co-operation and Development*. <https://www.oecd.org/coronavirus/policy-responses/coronavirus-covid-19-sme-policy-responses-04440101/>.

²⁷ Zoey Ye Zhang. 2019. "China's SOE Reforms: What the Latest Round of Reforms Mean for the Market." *China Briefing*. <https://www.china-briefing.com/news/chinas-soe-reform-process/>.

²⁸ Zhang.

While state-owned or directed businesses cannot compete with free-market efficiency or innovation, they benefit from significant government support and comparatively lower domestic competition. Although China no longer owns many manufacturing firms, the state still provides firms with favorable financing, tax benefits, predictable demand, and preferential trade agreements.²⁹ China offers the world's most generous subsidies, up to 40% of the costs for domestic semiconductor plants compared to only 15% in the U.S.³⁰ This high level of government support provides Chinese AM firms with a distinct advantage compared to U.S. SMEs struggling to maintain their solvency. Appendix-2, Figure 2 further highlights the firm strategy, structure, and rivalry between the U.S. and China. Russia's firm strategy, structure, and rivalry present some similarities to Chinese SOEs, however, the challenges are different with Russian manufacturing.

Firm Strategy, Structure, and Rivalry - Russia

Like China, Russian manufacturers transitioned from state to private control in the late 20th century. Through privatization, Russia sold many SOEs to politically connected elites or former factory workers, both highly unqualified to meet the challenges of a global economy.³¹ Under President Vladimir Putin, the Russian government did reassert state control of some firms. Russian SOEs are now primarily concentrated in related and supporting industries like energy and telecommunications as in China.³² Russia's history of state ownership and subsequent inept or corrupt private management have crippled Russia's manufacturing sector and decelerated Russian AM. These firms suffer from the same inefficiencies and lower innovation found in Chinese firms, but without government support.

Factor Conditions – United States

Porter believes Factor Conditions are those that an economy can create, such as capital, workforce, infrastructure, and innovation. Appendix-2, Figure 3 details specific U.S. - Chinese factor conditions with chance and government anchoring the model. The U.S. has capital resources, an innovation ecosystem, workforce, and information technology (IT) infrastructure highly favorable for Advanced Manufacturing. Compared to our competitors, capital is widely available in the United States. American banking and finance laws, regulations, and infrastructure make investing in U.S. companies secure and relatively easy.

²⁹ F. Joseph Dresen. 2012. "The Role of State Corporations in the Russian Economy." *The Wilson Center*. <https://www.wilsoncenter.org/publication/the-role-state-corporations-the-russian-economy>.

³⁰ Gregg IP. 2021. "China's Rise Drives a U.S. Experiment in Industrial Policy." *The Wall Street Journal*. <https://www.wsj.com/articles/chinas-rise-drives-a-u-s-experiment-in-industrial-policy-11615381230>.

³¹ F. Joseph Dresen. "The Piratization of Russia: Russian Reform Goes Awry." *The Wilson Center*. Accessed May 17, 2021. <https://www.wilsoncenter.org/publication/the-piratization-russia-russian-reform-goes-awry>.

³² Dresen. 2012.

Consequently, the United States is the world's largest recipient of traditional foreign direct investment and venture capital (VC).³³ These VC funds are critical to developing and new technologies and processes used in advanced manufacturing. Moreover, the U.S. innovation ecosystem is particularly adept at turning these investments into commercially viable ventures. A 2019 study of the world's largest economies showed the U.S. innovation base is the world's leader at translating academic research and basic science into economic returns.³⁴

America's educated and well-trained workforce helps drive this innovation ecosystem. U.S. workers are as much as three times more productive than their counterparts in low-wage countries like China. U.S. labor costs are comparable, if not superior, to many of our competitors when factoring in this productivity boost.³⁵ However, other nations are closing the gap or lead the U.S. in terms of manufacturing workforce development. American students strive to attend university and tend to shun vocational training and tech-heavy manufacturing jobs. A 2019 Harvard Business Review study of 40 million test subjects ranked 60 countries according to their "business, technology, and data science skills." The U.S. workforce did not break the top 25 percent in any measured category.³⁶ U.S. information resources and IT infrastructure also support national advanced manufacturing advantages. An average smart factory generates five petabytes of data per week (equivalent to the information held on 300,000 iPhones).³⁷ The U.S. has the necessary IT infrastructure and innovation base to support big data. As the Internet and World Wide Web creator, the United States has long been the global leader in IT infrastructure and software design. Eight out of ten of the world's most prominent software companies are currently incorporated in the U.S.³⁸ The U.S. leads in decision-support software and architecture programming, essential to the visualization and digital modeling used in advanced manufacturing, while clusters of software expertise exist in other countries.³⁹

The U.S. has many, but not all, the natural resources necessary to support advanced manufacturing. New processes in oil and natural gas production recently boosted U.S. manufacturing, especially in energy-heavy industries. By 2013, in the United States, natural gas

³³ *Foreign Direct Investment (FDI): United States*. 2020. U.S. Department of Commerce. <https://www.selectusa.gov/servlet/servlet.FileDownload?file=015t00000003D9M> and James Manyika, and William H. McRaven. 2019. "Independent Task Force Report No. 77, Innovation and National Security, Keeping Our Edge." The Council on Foreign Relations, 20, <https://www.cfr.org/report/keeping-our-edge/>.

³⁴ *National Innovation Policies: What Countries Do Best and How They Can Improve*. 2019. Global Trade and Innovation Policy Alliance, 5. National Innovation Policies: What Countries Do Best and How They Can Improve (itif.org).

³⁵ Helmuth Ludwig and Eric Spiegel. 2014. "America's Real Manufacturing Advantage." Manufacturing. No. 74. <https://www.strategy-business.com/article/00240?gko=c2d70>.

³⁶ Emily Glassberg Sands and Vinod Bakthavachalam. 2019. "Ranking Countries and Industries by Tech, Data, and Business Skills." *Harvard Business Review*. <https://hbr.org/2019/05/ranking-countries-and-industries-by-tech-data-and-business-skills>.

³⁷ Leo Craig. 2018. "How Data Will Build the Factories of the Future." *Techerati*. How data will build the factories of the future (techerati.com).

³⁸ Nathan Reiff. 2020. 10 Biggest Software Companies. *Investopedia*. <https://www.investopedia.com/articles/personal-finance/121714/worlds-top-10-software-companies.asp>.

³⁹ Helmuth.

cost just 33 percent of the price in Europe and 25 percent of the price in Asia. This energy advantage led to \$100 billion in new investment in U.S. manufacturing, including 100 new production plants.⁴⁰ However, this may be a fleeting advantage. U.S. energy policies change with each presidential administration, and other nations can increase domestic production to compete with U.S. prices. The U.S. lacks some other critical natural resources, such as Rare Earth Elements (REOs). In 2018, 100 percent of the rare earth elements used in U.S. manufacturing came from foreign sources, mainly China.⁴¹ While the ingredients are available in the United States, mining and processing REOs damage the environment and are hazardous to human health. Given America's emphasis on worker safety and environmental conservation, the United States may remain highly reliant on REO imports.

Factor Conditions - China

China maintains various factor conditions which support its robust and highly competitive manufacturing industry. China is regarded as the “world’s manufacturer,” outpacing the United States and other trailing nations to produce and export various products ranging from household goods to technically advanced products and systems. China’s high level of global manufacturing competitiveness strengthens its global economic status and supports the advancement of its national defense. The Chinese government has played a prominent role in bolstering China's global manufacturing competitiveness. The PRC government’s \$300 billion initial investment under Made in China 2025 to boost its manufacturing capabilities through research, development, and innovation demonstrates the advantages of China’s authoritarian government.⁴² Furthermore, China aims to establish a continued global dependency on its manufacturing industry. Chinese government leadership, loans, and sizable workforce have made its Belt and Road initiative possible to open up markets for Chinese manufacturers.

In the past, China’s 1.4 billion people provided a seemingly limitless supply of low-wage workers. For decades it has been an offshoring destination of labor-intensive manufacturing industries for many countries, including the United States. However, China’s aging population has led to a contraction of their labor-dependent manufacturing, triggering a deceleration of its economic growth. In response, the Chinese government raised the labor retiring age from 50 to over 60 years of age, improved wages and pensions, and invested in domestic and overseas academic and STEM opportunities for young people. China aims to promote, sustain, and enhance the quality of labor and productivity.⁴³

A heavily supported manufacturing ecosystem comprises Chinese industrial clusters, and special economic zones focused on technology and trade. The zones facilitate foreign exchange earnings, government revenue, export growth, technology transfer, and enhanced trade efficiency of domestic industries/markets.⁴⁴ China’s unique industrial clusters foster innovation across the

⁴⁰ Helmuth.

⁴¹ Sabri Ben-Achour. 2021. “The U.S. Is Trying to Reclaim Its Rare-Earth Mantle.” *Marketplace.org*. <https://www.marketplace.org/2021/04/30/the-u-s-is-trying-to-reclaim-its-rare-earth-mantle/>.

⁴² Ghosh, “The People’s Republic of China.”

⁴³ Banister, Bloom, and Rosenberg, “Population Aging and Economic Growth in China,” 1.

⁴⁴ Zeng, “China’s Special Economic Zones and Industrial Clusters: Success and Challenges,” 3–5.

various advanced manufacturing industries, which helps fill technological gaps and supports China's push towards transitioning from a manual labor-dependent manufacturing industry to an automated technologically advanced one.⁴⁵ As the global economy becomes increasingly interdependent from a worldwide source of specialized materials, China possesses a distinct advantage of being a significant source of raw materials relevant to the various advanced manufacturing industries.⁴⁶ China's access to and production of specialized and strategic rare earth materials drives further international dependence on Chinese manufacturing and supply chains.

Factor Conditions - Russia

As of January 1, 2021, the population of Russia was between 142.3⁴⁷ and 146.2 million people.⁴⁸ Russia's aging workforce will likely slow economic growth over the next two decades. With a projected birth rate of fewer than two children per woman, the total number of children born in the next ten years will be less than in the tumultuous 1990s.⁴⁹ Low immigration rates in the last decade, the low birth rate, and the high mortality rate among men will negatively affect the skilled workforce in Russia for the next two decades.^{50 51} To compensate, Russia may rely on migrant workers to supplement its manufacturing sector. Russia's best hope for migrant workers over the next decades is China. Still, rising salaries in China and the ruble's weakness are expected to discourage Chinese immigrants in the medium term. Russian anti-immigrant nationalism has also scared off economic migrants--approximately 500,000 people resettled in Russia in the last 15 years. Consequently, the skills base of Russia's workforce is eroding, and its education does not meet the needs of a modern economy. Highly automated intelligent manufacturing could lower production costs while boosting quality and efficiency, but this industrial transformation is in its infancy in Russia. Industrial automation in Russia also faces resistance because many Russians perceive automation as destroying jobs.⁵² Additionally, the lack of competent specialists in automation retards the introduction of the latest technologies.⁵³

⁴⁵ "The Benefits of Cluster Manufacturing – China's Advantage."

⁴⁶ "Raw Materials | Chinese Companies Dominate the World."

⁴⁷ The CIA world fact book field listing-population, Accessed on 7 May 2021, <https://www.cia.gov/the-world-factbook/field/population/>

⁴⁸ Federal State Statistics Service (in Russian), Accessed on 7 May 2021, <https://eng.rosstat.gov.ru>

⁴⁹ Data from Department of Workforce reports (in Russian), Accessed on 7 May 2021, <https://mintrud.gov.ru/docs/mintrud/analytics>

⁵⁰ The demographic yearbook of Russia for 2019 (in Russian), Accessed on 7 May 2021, https://rosstat.gov.ru/storage/mediabank/Dem_ejegod-2019.pdf

⁵¹ The demographic yearbook of Russia for 2019 (in Russian), Accessed on 7 May 2021, https://rosstat.gov.ru/storage/mediabank/Dem_ejegod-2019.pdf

⁵² Kartamisheva E., Industrial automation in Russia: problems and solutions. Young scientist. 2016, No^{28 (132)} (in Russian) Accessed on 2 May 2021. <https://moluch.ru/archive/132/36743/>

⁵³ Kartamisheva E., Industrial automation in Russia: problems and solutions. Young scientist. 2016, No^{28 (132)} (in Russian) Accessed on 2 May 2021. <https://moluch.ru/archive/132/36743/>

Russia's weak innovation culture plays a significant role in the low digitization of manufacturing. Russians are excellent inventors but abysmal innovators, as historical data shows. The lack of an innovative culture inhibits Russian researchers or companies from taking a product or process from the laboratory and delivering it to the market.⁵⁴ Russia's engineering push is constrained to a few technologies, resulting in a limited economic effect. Currently, only several discrete industries, such as aerospace and defense, are performing well, but their focus is on national security rather than added societal value and overall economic effect. Additionally, these industries' innovative capabilities are modest and advanced manufacturing will likely play a limited role in the near term.⁵⁵

Supporting and Related Industries – United States

The existence of Supporting and Related Industries in a competitive environment is the third quadrant of Porter's Diamond model. Appendix-4, Figure 4 highlights each nation's supporting and related industry factors. The presence or absence of these factors and how they interact with the Advanced Manufacturing sector help to define the nature of possible competitive advantage for the United States.⁵⁶ The National Institute of Standards and Technology (NIST) Office acts as the Advanced Manufacturing Program Office to partner through a network of manufacturing innovation institutes.⁵⁷ This National Network for Manufacturing Innovation (NNMI), also known as Manufacturing U.S.A, encourages collaboration between academia and federal partners to increase industrial competitiveness and foster a national advanced manufacturing infrastructure and research and development environment.⁵⁸ To date, there are 16 Manufacturing U.S.A institutes focused on different industries, supported by the Department of Defense, Department of Energy, and Department of Commerce, to the tune of \$3.6 billion.⁵⁹ The U.S. government has chosen the institute's hosts and locations based on the potential to create a positive economic impact, create jobs, increase nonfederal funding, how the institute will initiate educational and workforce activity, and how the institute will enhance economic competitiveness.⁶⁰

⁵⁴ Graham L., Russia's great at invention, but stinks at innovation, The Conversation, Accessed on 6 May 2021, <https://theconversation.com/russias-great-at-invention-but-stinks-at-innovation-35940>

⁵⁵ Schwab K., The Global Competitiveness Report 2019, World Economic Forum, Accessed on 5 May 2021, http://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf

⁵⁶ Dogan, Ismail Bakan & Inci Fatma. 2012. "COMPETITIVENESS OF THE INDU.S.TRIES BASED ON THE PORTER'S DIAMOND MODEL: AN EMPIRICAL STUDY." June. Accessed May 5, 2021. www.arpapress.com/Volumes/Vol11Issue3/IJRRAS_11_3_10.pdf.

⁵⁷ n.d. NIST OFFICE OF ADVANCED MANUFACTURING (OAM). Accessed May 5, 2021. www.nist.gov.

⁵⁸ n.d. Manufacturing U.S.A. Accessed May 5, 2021. www.manufacturing.gov.

⁵⁹ Service, Congressional Research. 2021. Manufacturing U.S.A: Advanced Manufacturing Institutes and Network. March 3. Accessed May 5, 2021. crsreports.congress.gov.

⁶⁰ Service, Congressional Research. 2021. *Manufacturing U.S.A: Advanced Manufacturing Institutes and Network*. March 3. Accessed May 5, 2021. crsreports.congress.gov.

U.S. intellectual property (IP) enforcement represents another advantage for advanced American manufacturing. IP enforcement is essential to American manufacturing and innovation. Consequently, international IP theft, estimated at \$250 billion annually, has a significant impact on the American economy.⁶¹ Cybersecurity has emerged as a critical element of national prosperity. From IP protection to data security and necessary infrastructure defense, the cyber threat is rising dramatically. The growing cybersecurity industry is essential to advanced manufacturing. Fifth-generation (5G) telecommunications will revolutionize advanced manufacturing. The new 5G systems will allow more efficient production control, data collection, and a more thorough understanding of customer behavior. Several high-tech companies, including Siemens, Amazon, General Electric, and IBM, use 5G to enable transformative technologies, including artificial intelligence and automation.

The United States risks losing access to specific essential manufacturing components and tools in the advanced technology realm. Recent semiconductor shortages have halted the manufacturing of consumer electronics and automobiles. Per Bloomberg, "Asia's two largest chipmakers are responsible for making most of the world's advanced silicon yet cannot sate all demand. It is a bottleneck that could last several quarters or into next year."⁶² The United States must address this vulnerability. Furthermore, advanced manufacturing relies on machine tools and quality assurance devices. Asia and Europe dominate machine tools and quality assurance devices.

Supporting and Related Industries - China

Transitioning to China's related and supporting industries, China's "Made in China 2025" aims to achieve 70 percent self-sufficiency in high-tech industries to seek the dominant position in global markets by 2049.⁶³ If fully realized by 2049, this policy could enable operations within the China ecosystem without reliance on any external factor. China has aggressively pursued this goal through forced technology transfers, cyber espionage, and intellectual property theft, causing significant concern and uneven playing fields for the United States.⁶⁴ Technology is a critical component to modernizing factories, and China's rapid rise in the high-tech and equipment manufacturing sectors aligns with the effort. To gain access to new technologies, China also targets participation in venture-backed startups. During the 2015-2017 time period, China accounted for 10-16 percent of all venture deals.⁶⁵ Therefore, China is exploiting the open U.S. economy by investing in the newest and most relevant technologies.⁶⁶

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Ash, Colonel Reggie. 2014. *American Bar Association Feature: Protecting Intellectual Property and the Nation's Economic Security*. June. Accessed May 5, 2021.

https://www.americanbar.org/groups/intellectual_property_law/publications/landslide/2013-14/may-june/protecting-intellectual-property-nations-economic-security/.

⁶² Ian King, Debby Wu, and Demtrios Pogkas, March 2021, How a Chip Shortage Snarled Everything From Phones to Cars, Why Is There a Chip Shortage? Covid-19, Surging Demand Cause Semiconductor Shortfall (bloomberg.com)

⁶³ "Is 'Made in China 2025' a Threat to Global Trade?"

⁶⁴ "Is 'Made in China 2025' a Threat to Global Trade?"

⁶⁵ Brown and Singh, 2.

⁶⁶ Brown and Singh, 2.

As China continues to invest heavily in artificial intelligence and robotics, these two areas will give Chinese factories a significant advantage as their population continues to age. China has been the top market for industrial robots since 2013 and will take delivery of 45 percent of all shipments through 202. The United States will only account for 7 percent.⁶⁷ With automation and artificial technology critical to the Industry 4.0 transformation, China has taken aggressive steps to ensure their factories continue advancing and increasing production. China boasts many clusters that can be engines for growth and innovation. For example, China's Pearl River Delta (PRD), with its nine mainland cities, accounts for approximately 5 percent of the total population and less than one percent of China's territory. However, the PRD generates more than 10 percent of China's economic output and attracts foreign direct investment surpassing the trillion-dollar mark.⁶⁸ While the PRD boasts labor-intensive and high energy consumption manufacturing, it has transitioned to high-tech sectors.⁶⁹

Supporting and Related Industries - Russia

Russia's weak manufacturing base and the paltry number of advanced technology sectors limit related and supporting industries and industrial clustering. Domestic suppliers create advantages through shortened supply chains and cost-effective inputs, but the lack of competition compromises this advantage for Russia. As a result, R&D and innovation remain limited and dependent on government funding. As one of the primary self-reinforcing inputs of the Porter diamond system, the lack of competitive supporting industries in Russia compromises overall national competitiveness.

Demand Conditions – United States

Porter makes the case that domestic demand conditions form one of the four determinants of national economic advantage. A national competitive advantage exists when strong home-market demand gives native firms a competitive advantage by providing an early and well-defined picture of buyer demands, making industries more competitive and ready to compete internationally, as shown in Appendix-3, Figure 5.⁷⁰ The U.S. possesses a well-established domestic consumer culture and base. Sparked by new manufacturing and distribution methods,⁷¹ the United States has the world's largest consumer market and the highest household spending.⁷² The size and maturity of the U.S. consumer market and its embrace of internet-based retailing generate solid domestic demand for manufactured products. Its culture of empowered individual consumer choice extends to U.S. businesses as well. "U.S. business firms enjoy greater flexibility than

⁶⁷ Tartar, "How China Is Creating the Factory of the Future."

⁶⁸ Fuller, "China's Crown Jewel."

⁶⁹ Fuller.

⁷⁰ Michael Porter, "The Competitive Advantage of Nations," Harvard Business Review, March-April 1990, <https://hbr.org/1990/03/the-competitive-advantage-of-nations/>.

⁷¹ Emily Remus, "Consumerism and Popular Culture—A Historiographical Survey," in *The Routledge History of the Twentieth-Century United States* ed. Jerald Podair and Darren Dochuk, Abingdon: Routledge, 18 May 2018.

⁷² The World Bank, "Households and NPISHs Final Consumption Expenditure," (2018), <https://data.worldbank.org/indicator/NE.CON.PRVT.CD?end=2018&start=1960/>.

their counterparts in Western Europe and Japan in decisions to expand capital plant, to lay off surplus workers, and to develop new products,⁷³ which translates to market-driven demand for manufacturing modernization.

The United States has enjoyed the benefits of high levels of domestic demand, a globally dominant economy, and overall steady growth since the end of World War II. However, the shift of global manufacturing from the United States to Asia,⁷⁴ the impact of recessionary cycles,⁷⁵ and the ongoing coronavirus pandemic create headwinds for its economic resilience and continued growth. As recently as 2017, the United States possessed the world's largest economy with a nominal gross domestic product (GDP) of \$21.43 trillion^{76,77} allowing it to enjoy robust home-market demand conditions for manufacturing products. However, China's four decades of unprecedented double-digit GDP growth has outpaced the slower-growing U.S. economy causing it to slip into second place.⁷⁸

Demand Conditions - China

The demand for Chinese products in the domestic market has decreased over the last few years primarily because of anti-globalization, the China-U.S. trade war, and the pandemic. As such, the country's long-term internationalization strategy is tuned to increase its reliance on the domestic market to safeguard China's economic security. This strategy was possible due to China's massive consumer market of 1.4 billion people. Precisely, China's most potent purchasing power is its middle-class population of over 400 million people. Predictions that East Asia will become the center of gravity for the global economy means that China is well-positioned to establish a cross-regional industrial and supply chain.⁷⁹ Moving forward, China's 14th Five-Year Plan promises to form a robust domestic market and facilitate an open dual circulation strategy with both domestic and foreign advanced manufacturing markets by 2025.⁸⁰

⁷³ CIA World Factbook, "United States," Accessed May 5, 2021, <https://www.cia.gov/the-world-factbook/countries/united-states/#economy/>.

⁷⁴ Peter Pham, "How Asia Has Become the World's Manufacturing Hub," *Forbes*, November 13, 2017, <https://www.forbes.com/sites/peterpham/2017/11/13/how-asia-has-become-the-worlds-manufacturing-hub/?sh=2eab721922cf/>.

⁷⁵ Kimberly Amadeo and Brian Barnier, "History of Recessions in the United States," *The Balance*, December 17, 2020, <https://www.thebalance.com/the-history-of-recessions-in-the-united-states-3306011/>.

⁷⁶ Based on 2019 World Bank data for Nominal GDP in current U.S. Dollars of \$21.43 trillion. When adjusted for Purchasing Power Parity (PPP) the U.S. trails China's \$23.52 trillion economy. World Bank, *World Development Indicators*, Accessed May 5, 2021, https://apps.bea.gov/iTable/iTable.cfm?reqid=150&step=3&isuri=1&table_list=211&categories=ugdpind/.

⁷⁷ Office of the United States Trade Representative, "Benefits of Trade," Executive Office of the President, Accessed May 5th, 2021, <https://ustr.gov/>.

⁷⁸ CIA World Factbook, "United States," Accessed May 5, 2021, <https://www.cia.gov/the-world-factbook/countries/united-states/#economy/>.

⁷⁹ Qingyang, "China's Turn towards Domestic Market amid Global Uncertainties — Good for the World?"

⁸⁰ "60 Key Points for Formulating the 14th FYP and Future Targets for 2035 - CGTN."

Demand Conditions - Russia

Demand conditions refer to various domestic and international demand aspects, including the quantity, quality, and degree of innovation in products manufactured.⁸¹ For Russia, all these matters and the sanctions play a significant role, limiting access to western markets. The sanctions play an ambivalent role – the inability to make alliances with other companies determines the demand and innovations and gives the Russian companies independence. Similarly, the dispersion of the customers over a large territory plays an ambivalent role too – from one side this influence manufacturing efficiency negatively, but from other become the main driver for Industry 4.0 technologies implementation.

Chance

In the Porters Diamond analysis context, Chance is defined as either a positive or negative externality beyond the control of the government or industry and monitor for its impact on market conditions. Although “chance” events cannot be changed, countries can plan for the occurrence and effects of adverse events such as natural disasters, domestic or international health crises, terrorists’ attacks, and conflict or positive events such as scientific advancements or technological breakthroughs. In comparison, China’s state-run industries have an inherent “unity of effort” through which the government can adjust the economy to mitigate the impact of a disruptive event. Conversely, the United States relies upon a market-driven economy, responding more to a focused customer demand signal. As a result, due to the necessity of “public will” to fuel national-level response actions, there is inherent latency between the event and response. Advanced manufacturing techniques such as additive (digital printing), injection molding, CNC milling, electron beam welding utilizing robotics, and artificial intelligence (IA) capabilities can speed U.S. industrial responses. Incorporating a re-designed production strategy coupled with a leaner, more agile manufacturing sector will produce lower-cost customized products based on need, reducing the necessity to mass-produce and stockpile materials. At the same time, reduce the reliance on an extended supply chain and foreign suppliers.

COMPARATIVE ANALYSIS OF STRENGTHS, WEAKNESSES, OPPORTUNITIES, AND THREATS

While Porter’s Diamond facilitates an understanding of the sources of a nation’s competitive advantage, this paper also employed an analysis to consolidate those factors by strengths, weaknesses, opportunities, and threats (SWOT) in consideration of the United States’ strategic competitors in the GPC to facilitate U.S. policy formulation. The analysis is primarily in contrast to China, as a near-peer competitor in advanced manufacturing. Although Russia poses strategic threats in other areas, based on Porter’s diamond analysis, it does not pose a distinct threat in manufacturing that warrants special consideration. Appendix-4, Figure 6 provides a three-country comparison table for reference.

⁸¹ Porter, M. E. 1990. „The competitive advantage of nations.“ *Harvard Business Review*. Accessed on 23 March 2021.

Strengths

Overall, the United States seems well-positioned across all components of Porter’s Diamond for national competitiveness in advanced manufacturing. As a free-market economy, the U.S. benefits from sophisticated customers who expect more value from the products and services purchased along with a firm strategy, structure, and rivalry that provides relatively easy access to capital. These conditions drive robust domestic competition and innovation due to relatively low barriers of entry and demand conditions. In addition, the strict rule of law and IP protection encourages innovation leading to a competitive advantage. Additionally, government initiatives such as Manufacturing Innovation Institutes incentivize public-private partnerships and adhere to the principles and efficiencies of the free market. Not choosing national champions, and allowing less profitable companies to exit the market, further encourages innovation, cost efficiencies, and productivity. The U.S. government also sponsors research and development with the private sector and academia through national labs and Department of Defense entities such as the Defense Advanced Research Projects Agency.

Factor conditions such as an IT infrastructure, information resources, and world-class research universities that are “homegrown” enable the pursuit of technological innovations more efficiently than China or Russia. The United States leads IT infrastructure and software design globally and has the potential in advanced manufacturing. In global rankings, the United States is home to 14 of the top 20 schools for general engineering in 2020.⁸² Collectively, these forces contribute to America's robust innovation ecosystem, which is difficult to replicate outside of a free market system.

Another example of the efficiency of the market is the “clusters” of related and supporting industries. Clusters are most notable in Silicon Valley, which has evolved more organically than a government-directed initiative like China. Although Manufacturing U.S.A. is a nationwide network for academia-public sector-private sector partnerships to collaborate in different areas related to advanced manufacturing development, it intends to build upon the existing local manufacturing hubs rather than contrive one where none existed. Furthermore, these alliances rely on voluntary participation, generally based on incentives with the government catalyzing to help industries move to higher levels of competitive performance.

The United States has a robust innovation ecosystem, stemming from the productive efficiencies of a market economy and responsive to market forces operating with minimal government interference. The minimal interference is not only economic theory but part of the American national culture.

⁸² The World University Rankings 2020, https://www.timeshighereducation.com/world-university-rankings/2020/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats

Weaknesses

Despite the value proposition of a market economy, it is imperfect, especially when viewed through the context of national and long-term economic security. For example, despite the United States having a concentration of the best research universities globally, this factor condition does not necessarily feed into the labor pipeline needed for advanced manufacturing. Data shows that enrollment of international students in U.S. science and engineering university programs has been steadily rising since 2008, while the number of U.S. citizens and permanent residents enrolled in those programs has steadily declined.⁸³ In addition, the lack of interest and the growing skills gap of the labor force and the labor needed for advanced manufacturing will likely need intentional government engagement.

The off-shoring of global value chains in manufacturing starting in the 1980s has contributed to the diminishing base of related and supporting industries necessary to leverage national competitive advantage in advanced manufacturing. Complex global supply chains have proven highly vulnerable to exogenous shocks and intentional attacks, especially for those products not easily sourced in the United States, such as rare earth elements and other raw materials. It has also led to an uncomfortable dependence on China, which creates a specific national security vulnerability. These weaknesses reflect where market forces fail to serve national security objectives. In this area, government engagement through partnerships and policies is needed. Ironically, it is also high-value manufacturing that provides ways to address these weaknesses. Advanced manufacturing offers a viable path to shorten global supply chains through flexible additive manufacturing, automation, and digitization connected to high-performance computing and factories of the future. In doing this, the United States can revitalize the industrial commons necessary for producing national prosperity.

In many ways, the weaknesses of the United States are China's strengths (and vice versa). This dichotomy frames the competitive space of advanced manufacturing. The U.S. economy has efficiencies and freedoms afforded under a market economy but results in gaps if the United States does not address China's national security objectives. The challenge for America is shoring up its weaknesses and taking advantage of opportunities while balancing government engagement within a free market economy in support of the manufacturing base.

China has significant shortcomings under Porter's Diamond. These areas include: establishing market liberalization policies to foster domestic competition, efficiency, and productivity, an aging population with diminishing cost advantage for labor, and an economy that is maturing and must find new drivers for growth. However, the Chinese government is leveraging its authority to direct a coordinated economic strategy focused on gaining a national competitive advantage in advanced manufacturing. The United States' long-term competitive advantage in advanced manufacturing requires policies that address gaps in its current advanced manufacturing strategy. The role of government is crucial for U.S. manufacturing to counter aggressive Chinese tactics, especially in closing the gap between TRL and MRL, incentivizing investments in R&D, and adopting advanced manufacturing technologies.

Opportunities

⁸³ 122 Herman, Arthur. "America's STEM Crisis Threatens Our National Security." *American Affairs Journal*, Spring 2019. <https://americanaffairsjournal.org/2019/02/americas-stem-crisis-threatens-our-national-security/>

The United States' foreign partners and allies offer an opportunity. With them, the United States can advance its manufacturing capabilities and global competitiveness and guide the establishment of international technology standards that favor U.S. companies. As advanced manufacturing has rapidly developed into a diverse global industry, America cannot singularly rebuild every necessary related and supporting industry nor secure every required resource, but its friends can help. Manufacturing's important role in the global economy provides the United States an opportunity to foster international manufacturing partnerships critical to bolstering U.S. competitiveness and supporting emerging and advanced nations. This would reduce dependence on China's manufacturing industry by promoting global stability and diversity in advanced manufacturing. Manufacturing's evolution into a technically advanced and automated form has created a less labor-dependent industry. China's manufacturing sector is traditionally heavily dependent on a cheap labor-intensive workforce. If China lags in transitioning to automation, there is an opportunity for the U.S. to widen the competitive gap in global manufacturing. Additionally, it allows the U.S. to potentially reallocate manufacturing to foreign partners and allies who would benefit from developing or modernizing their respective manufacturing capabilities.

Threats

Our competitors' rising GDP, manufacturing market share, workforce development, and unity of effort are the most significant threats to the U.S. advanced manufacturing industry. As China increasingly captures the global manufacturing market share and continues to invest in education, innovation and investments will flow out of the United States. China's deliberate and holistic efforts to enhance national innovation counterbalances the negative impacts its command economy and authoritarian government have on innovation.

Chinese state-led efforts such as Made in China 2025 provide centralized manufacturing policies that bind the Chinese government, private companies, and academia to achieve their goals of becoming a global innovation and technological leader for advanced manufacturing. Made in China 2025 has furthered other Chinese led initiatives, like the China Additive Manufacturing Action Plan⁸⁴ and China's innovative breakthroughs in additive manufacturing.

China also presents a threat to the United States and other industrialized democracies because the international community cannot easily restrain China or hold it accountable for international trade violations, especially those involving intellectual property (IP). For example, China frequently recruits foreign scientists and targets acquiring U.S. and other foreign high tech industry firms. The Chinese government also seeks to dominate standard-setting bodies, lowering global health and safety standards for new technologies and goods.

⁸⁴ “China Introduces New Action Plan for Advancement of 3D Printing Industry,” 3DPrint.com | The Voice of 3D Printing / Additive Manufacturing, December 14, 2017, <https://3dprint.com/197397/china-action-plan-3d-printing/>

POLICY RECOMMENDATIONS

The following U.S. government policy recommendations support a unified national strategy to encourage innovation. They address academia or large companies and the small and medium-sized businesses that are the heart and soul of American industry. These small and medium-sized firms generally have a more difficult time bridging the technology or manufacturing valley of death for emerging ideas. After analyzing the United States and its great power competitors' markets and industrial systems world with Porter's Diamond and SWOT, there emerged five common challenges, concepts, or opportunities that will accelerate American advanced manufacturing.

Promote U.S. International Standards for Advanced Manufacturing

As identified in the SWOT analysis, the United States has an opportunity to foster partnerships that bolster U.S. global competitiveness. Per the Porter's Diamond model, governments can shape the international environment where U.S. companies compete.

Unified standards provide the fundamental pillars to interoperability, safety, and functionality. Without suitable international standards in advanced manufacturing, bad actors who produce dangerous products or adopt illegal practices will have an unfair advantage—identified in the SWOT analysis under threats. This impacts U.S. trade and innovation.⁸⁵ The Chinese Communist Party also recognizes how standards will give it a competitive advantage. As a result, China has doubled its policies to influence international standards, and the nation's participation in international standards-setting organizations (SSO) increased by 75 percent between 2011 and 2019.⁸⁶

In January of 2021, the U.S. Department of Commerce's National Institute of Standards and Technology (NIST) awarded \$4 million in grants to four American organizations to hasten new standards that will advance America's competitive advantage in advanced manufacturing. According to the U.S. Secretary of Commerce, NIST is committed to providing resources to U.S. organizations to encourage more innovation.⁸⁷ Indeed, NIST plays a critical role in promoting collaboration with academia, industry, and government that drives innovation. While NIST and the State Department work with allies and partners to ensure U.S. standards and measurements are practical, the absence of unified, international standards in advanced manufacturing hinders innovation and economic growth for the United States.

To mitigate these challenges—through diplomacy—the United States should lead within the World Trade Organization (WTO) and international standards-setting bodies to gain buy-in from global partners and establish international standards for advanced manufacturing, including environmental ethics. The United States can promote a multi-national agreement that will boost the economic power of critical partners and allies and advance American economic interests. U.S. leadership in establishing international standards for advanced manufacturing reduces barriers and opens the borders to increased trade and innovation by U.S. industry.

⁸⁵ “Strategy for American Leadership in Advanced Manufacturing,” 5.

⁸⁶ (<https://www.chinabusinessreview.com/chinas-participation-in-international-standards-setting-benefits-and-concerns-for-us-industry/>)

⁸⁷ “NIST Awards Nearly \$4 Million to Support Metals-Based Additive Manufacturing.”

There are political risks to consider when applying this policy. For example, historically, conservatives have apprehensions about “big government” determining global winners and losers.⁸⁸ While multi-national agreement on standards would improve collaboration between key partners, determining *which* key partners to work with could also be politically fraught. In the end, international standards only work when agreements are honored and nations are consistent. Therefore, there must be a bipartisan agreement on the selection of international partners and evaluating compliance.

In addition to associated or inherent risks, policymakers must consider the impact of chance externalities in applying this policy recommendation. As it relates to the Porter's Diamond model, the U.S. must be prepared to provide sufficient support, including economic and financial, to maintain allies' and partners' support regarding international standards. This is critical as the impact of natural disasters or economic uncertainty can drive a country aligned with the U.S. to other partners to maintain its national security and integrity.

Develop and Strengthen International Advanced Manufacturing Partnerships

The United States should prioritize the development of international advanced manufacturing partnerships. As assessed in the SWOT analysis, such agreements serve as a counterweight to China's state-run advanced manufacturing initiatives. Additionally, partnership initiatives would help bolster the U.S. factor conditions, as identified in Porter's Diamond analysis. In the past, U.S. companies have benefited from off-shoring manufacturing to nations such as China, creating U.S. and ultimately global dependence on China's supply chains. To tip the global manufacturing competitive scale towards the United States, the U.S. government must lead the creation of favorable foreign trade agreements, partnerships, and alliances. This would facilitate a more diverse global supply chain and diminish U.S. and global dependency on China's manufacturing industry.

Solid partnerships and alliances within the international advanced manufacturing community are necessary to ensure critical infrastructure is secured. The United States 2018 *Strategy for American Leadership in Advanced Manufacturing* provides a domestic vision and priorities for advanced manufacturing.⁸⁹ While this strategy provides a sound policy foundation, it is also narrow and only emphasizes domestic initiatives.⁹⁰

While a potential risk, the United States and its allies should also consider collaborating - under certain conditions -- with China as a manufacturing leader. This U.S.-led international coalition could promote and influence healthy collaboration and transparency from China while enhancing limits on its access to dual-use technologies. Developing, strengthening, and maintaining international advanced manufacturing partnerships is of equal importance to boosting domestic advanced manufacturing capabilities. To accomplish these vital partnerships, both the U.S. Government and domestic public-private advanced manufacturing organizations must better coordinate on U.S. national strategy. To codify these foreign partnerships, international advanced manufacturing strategic doctrine should allow collaboration by participating countries, supporting public-private partners, and academia. This would facilitate global standard-setting, shared priorities, security threat mitigation, and the sharing of resources.

⁸⁸ <https://www.washingtonpost.com/technology/2020/12/01/us-policy-china-technology/>

⁸⁹ “Strategy for American Leadership in Advanced Manufacturing,” 40.

⁹⁰ “Strategy for American Leadership in Advanced Manufacturing,” 26–29.

Provide High-Performance Computing Resources to Enable Data-Driven Manufacturing

As identified in the Porter's Diamond analysis, U.S. manufacturers are highly innovative but do not receive the same level of government support as their foreign competitors. Without government assistance, U.S. SMEs often lack the capital resources and expertise to adopt transformative AM practices. Data-driven manufacturing programs and High-Performance Computing (HPC) services can provide competitive advantages to these SMEs by lowering design and testing costs, accelerating product development lifecycles, and reducing material and labor waste.⁹¹ Although widely available, these tools are expensive (particularly for SMEs) and require in-depth knowledge to maximize their potential. Therefore, U.S.-based SMEs are slow to integrate data threads and HPC into their manufacturing processes. In cooperation with the Federal Communications Commission (FCC) and Networking and Information Technology Research and Development Program (NITRD), Manufacturing U.S.A. should develop national advanced manufacturing knowledge communities to bring data-driven manufacturing to SMEs. Using subsidized HPC networks, these communities can collaborate on long-term projects with private, government, and academic partners using shared data sets. This network-focused strategy promotes innovation and encourages SMEs to adopt advanced manufacturing practices faster than relying on companies to invest in stand-alone, proprietary networks.

Unlike the United States, China and the EU have dedicated national programs that provide network access and education to manufacturing SMEs. China's ongoing Tianhe Industrial Cloud Program (TICP) built a public/private partnership focused on reducing manufacturers' research, design, and development costs. The program partners academic researchers with government and industry users on long-term projects and offers each participating company up to 40 million Yuan (\$6.1 million) in economic benefits.⁹² Similarly, the EU's "EuroHPC Joint Undertaking" shares the resources of 32 nations to develop industrial HPC applications.⁹³ Together with subsidized networks, these programs lower SMEs' costs and attract new users. On average, broadband internet is now 50 percent faster and 27 percent cheaper in Asia than in the United States. The Asia-Pacific region is the fastest-growing HPC market with a 7.9 percent CAGR (1.77 percent above the global average).⁹⁴ ⁹⁵ China also found

⁹¹ Dennis J.L. Siedlak, Olivia J. Pinon, Paul R. Schlais, Todd M. Schmidt, and Dimitri N. Mavris. "A Digital Thread Approach to Support Manufacturing-Influenced Conceptual Aircraft Design." *Research in Engineering Design* 29, no. 2 (2018): 285-286.

⁹² Changsong Li, Yuchen Jiang, and Pengcheng Fang. 2019. "Innovation in Advanced Manufacturing Driven by Supercomputing." *ScienceDirect* No. 83, 558.

⁹³ The European High-Performance Computing Joint Undertaking – EuroHPC JU. 2021. European Commission, 10. <https://digital-strategy.ec.europa.eu/en/policies/eurohpc-ju>.

⁹⁴ "The Cost of Connectivity 2020: Global Findings." 2020. *New America*. <https://www.newamerica.org/oti/reports/cost-connectivity-2020/global-findings/>.

⁹⁵ "High-Performance Computing Market Size, Share & Trends Analysis Report By Component (Servers, Services), By Deployment (On-premise, Cloud), By End-use, By Region, and Segment Forecasts, 2020 – 2027." 2020. *Grand View Research*. GVR_2-68038-492-5.

that after learning how to use HPC through nationally funded networks, many businesses invest in their own hardware and form their new networks.⁹⁶

In addition to lowering cost and accelerating adoption, advanced manufacturing knowledge communities built around shared networks encourage innovation. By providing collaborative networks to multiple users with shared datasets, Chinese firms exponentially grew the number of indigenously produced manufacturing software programs and have become a world leader in the field.⁹⁷ The EU has taken a similar approach by creating nine industry-specific "Data Spaces." While industry partners are required to provide a certain degree of proprietary data, in exchange, they gain access to a broader data pool and the analytic tools all participating members develop.⁹⁸ The EU expects this approach will allow their manufacturing sector to capture up to €1.5 trillion (\$1.83 trillion) in new value by 2027.⁹⁹ This is a tremendous economic benefit compared to the cost. The EU expects EuroHPC Joint Undertaking will cost partner nations €9.1 billion (\$11 billion) over 15 years.¹⁰⁰

A partnership between Manufacturing U.S.A., the FCC, and NITRD is an essential element of this strategy. The NITRD is the federal government's office of primary responsibility for network investment; however, they do not follow a national-level approach. The NITRD simply compiles budget requests and development plans from various government agencies.¹⁰¹ Similarly, the FCC does not have the knowledge or expertise to build network infrastructure to support specific industries. Recent FCC regulation and industry advocacy targets expanding broadband access to rural areas, not geographic industry clusters.¹⁰² Working with these agencies, Manufacturing U.S.A. can identify the key cities, users, and subsidies necessary to bring collaborative HPC networks to SMEs.

The primary risk of connecting commercial, academic, and government users is the increased vulnerability to cyber-attacks. While cyberattacks are highly probable, protective measures can quickly lower their consequences and overall risk. Many SMEs do not have the capital or personnel to invest in robust cybersecurity programs or stay abreast of current threats and best practices. These individual firm networks are generally more vulnerable to cyberattacks than a consolidated, professionally run network with dedicated security staff.¹⁰³ While consolidating users on a single, collaborative network increases the size of the target, it also

⁹⁶ Zhiwei Xu, Xuebin Chi, and Nong Xiao. 2016. "High-Performance Computing Environment: A Review of Twenty Years of Experiments in China." *National Science Review*. No 3, 41.

⁹⁷ Zhiwei, 39.

⁹⁸ *A European Strategy for Data*. 2020. European Commission, Communication from the Commission to the European Parliament. No. 66, 26-27. <https://op.europa.eu/en/publication-detail/-/publication/ac9cd214-53c6-11ea-aece-01aa75ed71a1/language-en>.

⁹⁹ *A European Strategy for Data*, 22.

¹⁰⁰ *Hearing Before the Committee on Science, U.S. House of Representatives*. "Supercomputing: Is the U.S. on the Right Path?" No. 108-21, July 16, 2003, 24.

¹⁰¹ "The Federal Networking and Information Technology Research and Development Program: Background, Funding, and Activities." 2017. *Congressional Research Service*, RL33586. Washington, D.C., 1-3.

¹⁰² Sean Hollister. 2020. "In 2021, We Need to Fix America's Internet." *The Verge*. <https://www.theverge.com/22177154/us-internet-speed-maps-competition-availability-fcc>.

¹⁰³ U.S. Department of Energy. "Industry Studies 15." National Defense University (Virtual), Washington, D.C. March 4, 2021.

eliminates many of the vulnerabilities inherent to the current ad hoc network approach. This increased security offsets the risk of consolidating users on collaborative networks.

Policymakers must be mindful of the impact of chance externalities. As defined in the Porters Diamond analysis, chance events are unpredictable. Still, leaders must consider the disruptive effects on resources (budgets, equipment, and personnel) and time part of the planning process while transforming or upgrading manufacturing capabilities and processes. The most recent cyber-attack on the colonial fuel pipeline demonstrates the negative impact on a nation's ability to function and protect itself when critical infrastructure relies upon outdated and vulnerable technology.

Subsidize U.S. Research and Development and Capital Investment Through Tax Policy

One of the most significant policy differences between the United States and the PRC is the direct subsidization of corporate R&D and manufacturing by the Chinese government. For fiscal, political, and philosophical reasons, the United States is unlikely to match PRC subsidies. There is disagreement on whether direct federal funding would be the most efficient or even WTO-compliant path to stimulate U.S. manufacturing. However, U.S. policy changes are necessary to counter the market distortions generated by PRC subsidies and improve the competitiveness of the American manufacturing base.

Today, the U.S. government spends only half as much on R&D as it did during the Cold War. Yet, over this same period, business investment in R&D has increased 200%, making private businesses the primary investor in U.S. R&D.¹⁰⁴ Venture Capital (VC) funding accounts for an increasing percentage of these private funds. In 2018, U.S. businesses received more than half of the world's seed-stage VC funds.¹⁰⁵ Venture capitalists typically demand higher and more immediate returns on their investments than long-term, value investors. U.S. investors expect the average VC-backed start-up company to earn positive revenue in just 18 months.¹⁰⁶ Therefore, while the decreasing pool of government research funds still supports basic science and technology (Technology Readiness Levels 1 & 2), VC funds typically support only proven technologies (TRL 6+). This short-term focus leaves a significant R&D gap in TRL 3, 4, and 5, the proverbial "valley of death."

Much of this VC investment is focused on the higher-margin, less capital-intensive U.S. technology sector. Companies invest enormous sums into R&D in expectation of substantial returns on investment (ROI).¹⁰⁷ ¹⁰⁸ However, investments of similar scale are not common in manufacturing, where net margins are much smaller. As a result, small and mid-size U.S.

¹⁰⁴ *U.S. Official News*. 2017. "Washington: DOD Is Taking Steps to Address Challenges Faced by Certain Companies." United States Government Accountability Office. GAO-17-644, 1.

¹⁰⁵ James Manyika, and William H. McRaven. 2019. "Independent Task Force Report No. 77, Innovation and National Security, Keeping Our Edge." The Council on Foreign Relations, 20, <https://www.cfr.org/report/keeping-our-edge/>.

¹⁰⁶ Manyika, 29.

¹⁰⁷ Sharwood, Simon, "Microsoft's Five-billion-buck IoT R&D Plan is Just Business as Usual," *The Register*, April 6, 2018, https://www.theregister.com/2018/04/06/microsoft_internet_of_things_research_budget/.

¹⁰⁸ Dale Buss, "Examining the ROI of R&D," *Chief Executive*, May 18, 2011, <https://chiefexecutive.net/examining-the-roi-of-rd/>.

manufacturers are less likely to innovate and remain on the leading edge of technology. In the United States, direct federal funding of commercial R&D has proven less efficient than efforts led by the private sector, as businesses have proven better able to respond quickly to the dynamic consumer market. However, U.S. policy could encourage R&D in advanced manufacturing to assist U.S. industry through the expansion of Internal Revenue Service code section 174, which provides a tax deduction for "research and experimentation."¹⁰⁹

In December 2017, then-President Trump signed the Tax Cuts and Jobs Act (TCJA), notionally to improve the competitiveness of U.S. businesses. However, changes to the tax code may have the opposite effect, altering how companies deduct their R&D.¹¹⁰ Starting in 2022, companies may amortize domestic R&D costs over five years, and foreign investments would be expensed over 15 years.¹¹¹ This requirement to amortize or R&D expenses over a prolonged period is not favorable to U.S. corporations. U.S. tax policy for businesses, especially in targeted R&D areas and advanced manufacturing industries, should allow for immediate depreciation to free corporate capital for R&D and incentivize an environment favorable for innovation. Similarly, the TCJA phased out the total expense deduction for short-lived assets such as machinery and software, again directly impacting the competitiveness of U.S. manufacturers.¹¹² And while the TCJA reduced the corporate tax rate to improve U.S. competitiveness, additional effort is needed. According to a joint study by the Manufacturers Alliance for Productivity and Innovation (MAPI) and NAM, America's pollution abatement costs are higher than those of any of its major trading partners".¹¹³ President Biden has proposed raising the corporate tax rate to 28 percent, making U.S. corporations among the most heavily taxed in the developed world. Unless this change is coupled with deductions and incentives to reward R&D and high-capital investments, the change will negatively impact U.S. manufacturing's competitiveness.

Congress and the Biden administration should collaborate to amend the TCJA to create a corporate tax policy that genuinely supports the competitiveness of U.S. manufacturers. If the current fiscal situation requires an increase in the corporate tax rate to raise additional government revenues, the increase should be coupled with credits or deductions for R&D and capital investments so that U.S. manufacturers are better positioned to compete with China. Congress should also amend the TCJA to allow full, same year amortization of R&D and capital investment costs by manufacturers in crucial industries. The Congressional Budget Office should

¹⁰⁹ Organization for Economic Co-Operation and Development, "The Effects of R&D Tax Incentives and Their Role in the Innovation Policy Mix," *OECD Science, Technology and Industry Policy Papers*, no.92, (2020), https://www.oecd-ilibrary.org/science-and-technology/the-effects-of-r-d-tax-incentives-and-their-role-in-the-innovation-policy-mix_65234003-en/.

¹¹⁰ Joint Committee on Taxation, "General Explanation of Public Law 115-97," JCS-1-18, December 2018, <https://www.govinfo.gov/content/pkg/CPRT-115JPRT33137/pdf/CPRT-115JPRT33137.pdf/>.

¹¹¹ Justin Silva, "Tax Cut and Jobs Act Changes to Section 174 Rules: Planning for Future Required Amortization of Research Expenses," *RSM*, January 10, 2018, <https://rsmus.com/what-we-do/services/tax/credits-and-incentives/tax-cut-and-jobs-act-changes-to-section-174-accounting-method-ru.html/>.

¹¹² U.S. Congress. Tax Cuts and Jobs Act of 2017.

¹¹³ Stephen Gold, U.S. Chamber of Commerce Foundation, "A U.S. Manufacturing Strategy," <https://www.uschamberfoundation.org/bhq/us-manufacturing-strategy>

provide a cost-benefit analysis demonstrating the long-term wealth generated by establishing leadership in critical sectors, offsetting the short-term loss of revenues. However, there are risks: concerns over the size of the federal budget deficit may drive Congress to prioritize short-term funding to pay for more immediate and tangible needs. Also, bi-partisan disagreement and the narrow margin of control by the majority party in Congress may result in legislative gridlock that prevents any new legislation.

As the U.S. relies upon market forces to drive economic trends and investments, the impacts of chance events will dramatically shift the value of the investments over time. Whereas the CCP can adjust short-term effects through subsidies, U.S. investment strategy must be resilient to withstand the impact of a negative externality and rely upon the strength of time to realize the optimal return on investment.

Provide Career and Technical Education for a 21st Century Workforce

U.S. manufacturing is a shadow of what it was in mid-century America. As manufacturing has fallen from 40 percent of U.S. GDP to less than 12 percent, the U.S. manufacturing workforce has fallen even further. It now accounts for only 8.5 percent of all U.S. workers.¹¹⁴ As the Porters Diamond and SWOT analysis noted, to support an expansion of advanced manufacturing, the United States must expand its advanced manufacturing workforce.

The Trump Administration's *Strategy for Leadership in Advanced Manufacturing* echoes the often-cited need to restore manufacturing's image in the eyes of students, parents, and teachers. Industry 4.0 is not "dark, dirty, and dangerous." As China and Germany do, U.S. educators should expose children in primary and secondary school to career and technical education (CTE), including advanced manufacturing. In most industrialized countries, high school students can opt for full-time vocational education.¹¹⁵ After a decades-long decline in the United States, some states are restoring CTE to high schools, but national and local governments should do more.¹¹⁶ In the United States, junior and community colleges and public vocational institutes provide most technical education. Congress should increase funds for advanced manufacturing training, investing in teachers, technology, and industry coordination.

Another feature of high-performing national CTE is the pervasiveness of apprenticeships. In Germany, a country of 83 million, companies take in over 500,000 new apprentices every year

¹¹⁴ "2019 U.S. Manufacturing Facts," National Association of Manufacturers, Accessed May 7, 2020. <https://www.nam.org/state-manufacturing-data/2019-united-states-manufacturing-facts/#:~:text=Manufacturers%20in%20the%20United%20States,employing%208.51%25%20of%20the%20workforce>

¹¹⁵ Spees, Ann-Cathrin, "Could Germany's Vocational Education and Training System be a Model for the U.S.?" June 12, 2018, World Education News and Reviews, World Education Services. <https://wenr.wes.org/2018/06/could-germanys-vocational-education-and-training-system-be-a-model-for-the-u-s>

¹¹⁶ Brian A. Jacobson, "What we Know about Career and Technical Education in High School." Brookings Institution, October 5, 2017. <https://www.brookings.edu/research/what-we-know-about-career-and-technical-education-in-high-school/>

as part of the German national CTE program.¹¹⁷ By contrast, in the United States, with a total population of 328 million people, only 252,000 people (about half the population of Wyoming) began an apprenticeship in 2019. Furthermore, most of those apprenticeships were in the construction and Industry 3.0 fields. Workforce Innovation and Opportunity Act money could expand workforce development boards and boost Labor Department capacity to encourage advanced manufacturing companies' participation in the Department's registered apprenticeship program.

The Labor Department and industry leaders report shortages of highly educated science and technology professionals necessary to innovate and implement advanced manufacturing solutions. Until the United States can organically increase its university-trained STEM workforce to fill shortages, it should increase the number of H1-B visas from its current level of 65,000. With a projected deficit of over 2 million advanced manufacturing workers by 2028, industry would absorb exponential increases in H1-Bs. Allowing in more educated professionals would not disadvantage Americans seeking advanced manufacturing work; on the contrary, more workers would enable the sector to expand, creating more jobs.

Improvements to high school, post-secondary, and apprenticeship programs will require modest funding increases. An additional \$2 billion (about \$6 per American) per year would go far to improving U.S. CTE programs. Congress could fund the increases through a .28 percent decrease in the Defense Department budget.¹¹⁸ A risk to this approach is that Defense Department reductions could impact readiness, acquisition, or other mission essential defense programs. However, because the additional funds are intended to increase national security, legislators would be justified in a minuscule, temporary reduction in the Department of Defense's budget to boost CTE. In addition, an increased H1-B cap would raise several tens of millions of dollars of additional money each year. H1-B charges include the American Competitive and Workforce Improvement Act fee of \$750 or \$1,500, depending on the company's size filing the H1-B petition. Regarding the potential unpopularity of increased immigration, as the profile of advanced manufacturing rises and economic competition with China becomes starker in the minds of Americans, support for immigration from partners and allied countries to bolster the American workforce could rise.

CONCLUSION

The turn of the century saw America's lead in manufacturing evaporate as globalization restructured the DIB, increasing U.S. reliance on a fragile and internationally sourced supply chain. As the DoD warned in the *Fiscal Year 2020 Industrial Capabilities Report to Congress*, a declining manufacturing sector risks "a growing and likely permanent national security deficit." The Interim NSS and this paper's analysis identify China as the only rival capable of combining its instruments of power to challenge the United States endeavors. Moreover, the economic value of China's advanced manufacturing sector is increasing due to Beijing's commitment to becoming the superpower. As China reasserts its influence globally and fields new military

¹¹⁷ "Apprenticeship in Germany," German Federal Institute for Vocational Education and Training (BIBB), October 4, 2019, <https://www.apprenticeship-toolbox.eu/germany/apprenticeship-system-in-germany/143-apprenticeship-system-in-germany>

¹¹⁸ "America off Balance," Hoover Institute, Stanford University, accessed May 11, 2021. <https://americaoffbalance.org/>

capabilities, the United States must take action to ensure America's dominance over its great power competitors in the 21st century. Indeed, winning the global contest for power and influence requires leading the world in advanced manufacturing.

Using the Porter's Diamond Model, this paper evaluated America's competitive advantage and identified root causes that deter progress. The 2018 *Strategy for American Leadership in Advanced Manufacturing* was a helpful starting point but lacked an international focus or more concrete policy actions. This paper found that to lead the world in advanced manufacturing, the United States must execute five critical policies that support a U.S. manufacturing renaissance.

- **Promote U.S. International Standards for Advanced Manufacturing.** Unified standards provide the fundamental pillars to interoperability, safety, and functionality. Without suitable international standards in advanced manufacturing, bad actors who adopt illegal practices will have an unfair advantage.
- **Develop and Strengthen International Advanced Manufacturing Partnerships.** To tip the global manufacturing competitive scale towards the United States, the U.S. government should establish favorable foreign trade agreements, partnerships, and alliances. This would facilitate a more diverse global supply chain and diminish U.S. and global dependency on China's manufacturing industry and supply chains.
- **Provide High-Performance Computing Resources to Enable Data-Driven Manufacturing.** Data-driven manufacturing programs and High-Performance Computing (HPC) services can provide competitive advantages to SMEs by lowering design and testing costs, accelerating product development lifecycles, and reducing material and labor waste.
- **Subsidize U.S. Research and Development and Capital Investment through Tax Policy.** The U.S. government must amend the TCJA to create a corporate tax policy that genuinely supports the competitiveness of U.S. manufacturers, better positioning companies to compete with China.
- **Provide Career and Technical Education for a 21st Century Workforce.** As the Porters Diamond and SWOT analysis noted, to support an expansion of advanced manufacturing, the United States must expand its advanced manufacturing workforce.

These recommendations form the foundation of an integrated economic and industrial strategy that balances technological innovation with high-value production output. While there are substantial risks to consider when applying these policies, America's national security is at greater risk if it does not outpace its rivals' production capacities. Moreover, this strategy must be long-term and enduring through administration changes and political party agendas. Finally, it must set the conditions for the U.S. to influence transformational change and improve the way humans function and societies operate. This will enhance the security posture while stabilizing and safeguarding the environment for future generations.

APPENDIX-1

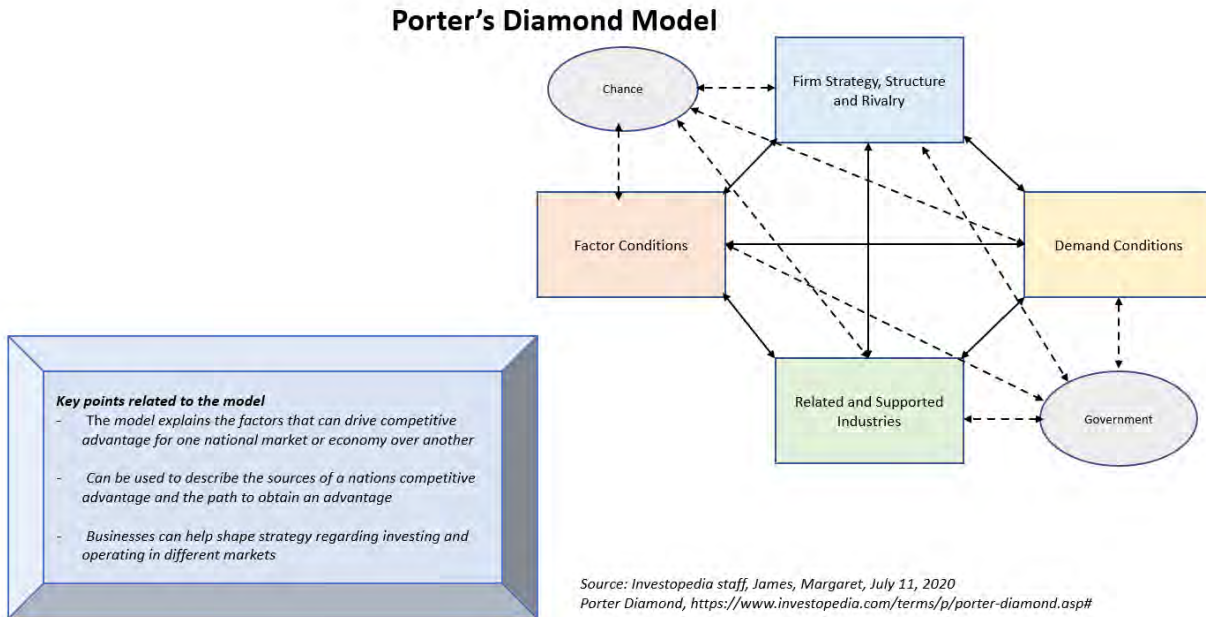


Figure 1: Porter's Diamond Model of National Advantage¹¹⁹

¹¹⁹ Porter, Michael. "The Competitive Advantage of Nations." Harvard Business Review. March-April 1990.

APPENDIX-2

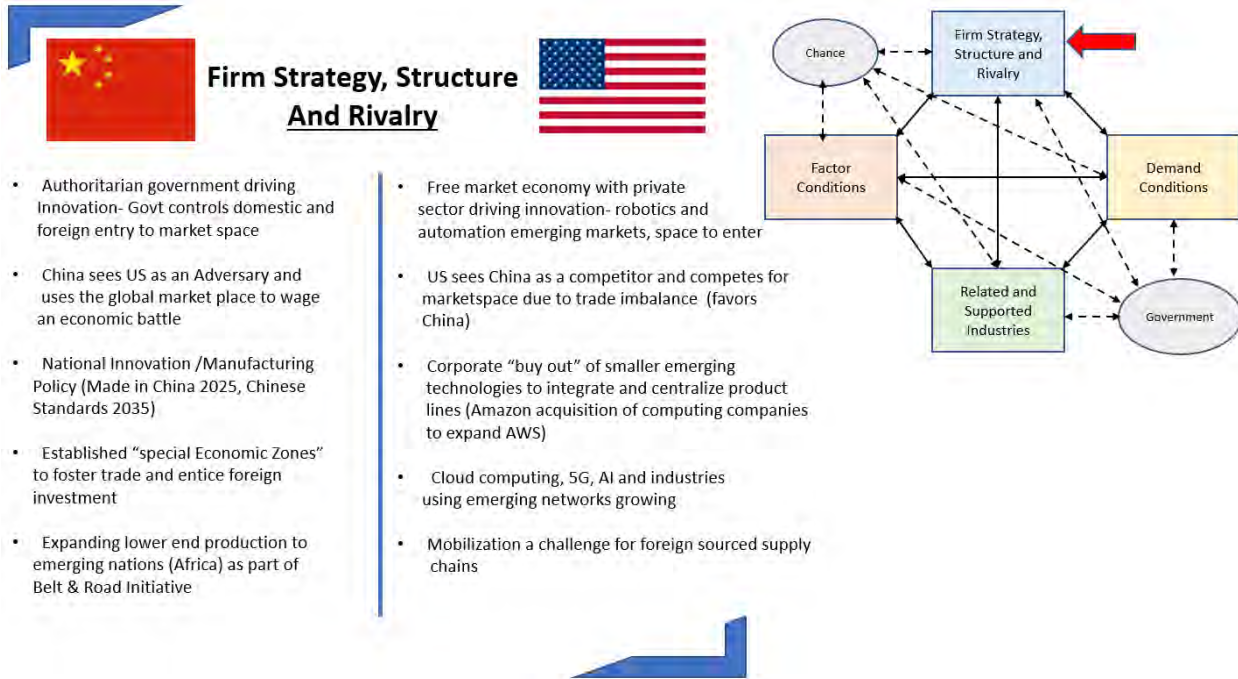


Figure 2: Porter’s Diamond Model - Firm Strategy, Structure and Rivalry

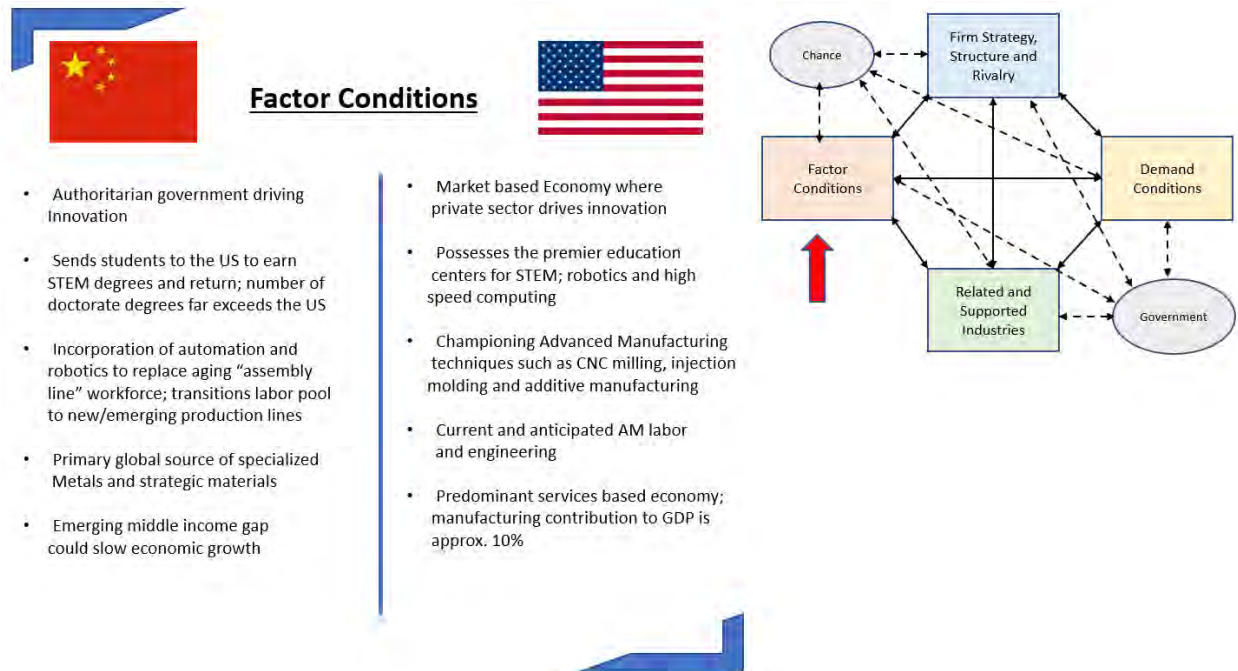


Figure 3: Porter’s Diamond Model - Factor Conditions

APPENDIX-3

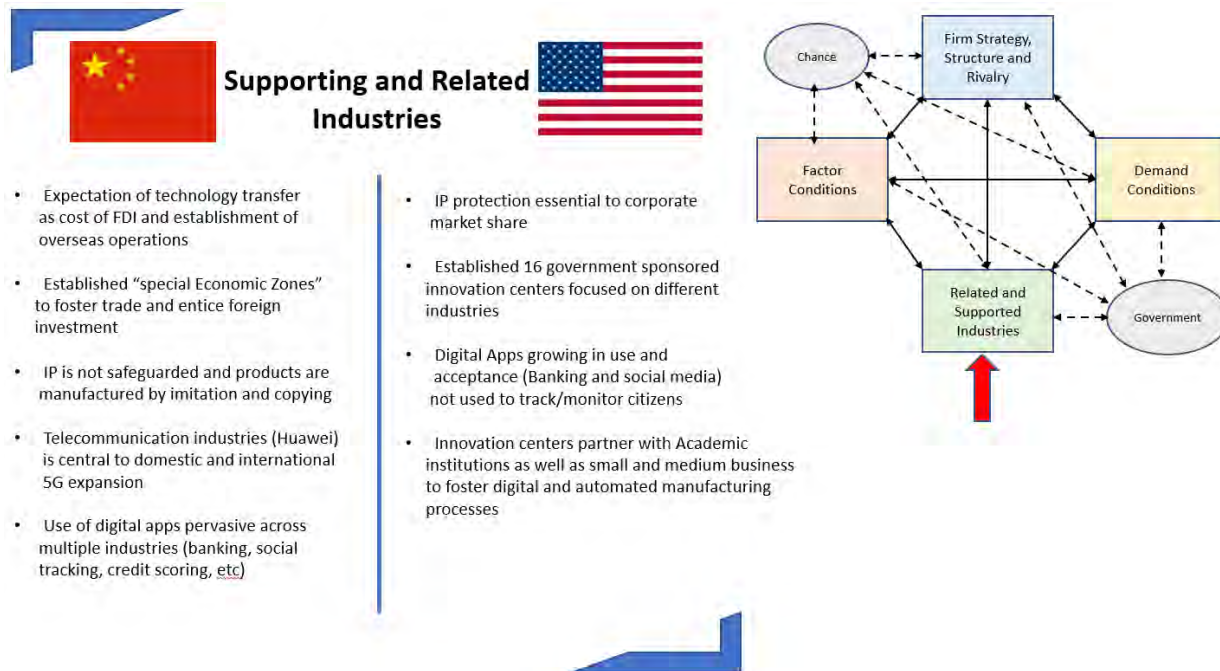


Figure 4: Porter’s Diamond Model - Supporting and Related Industries

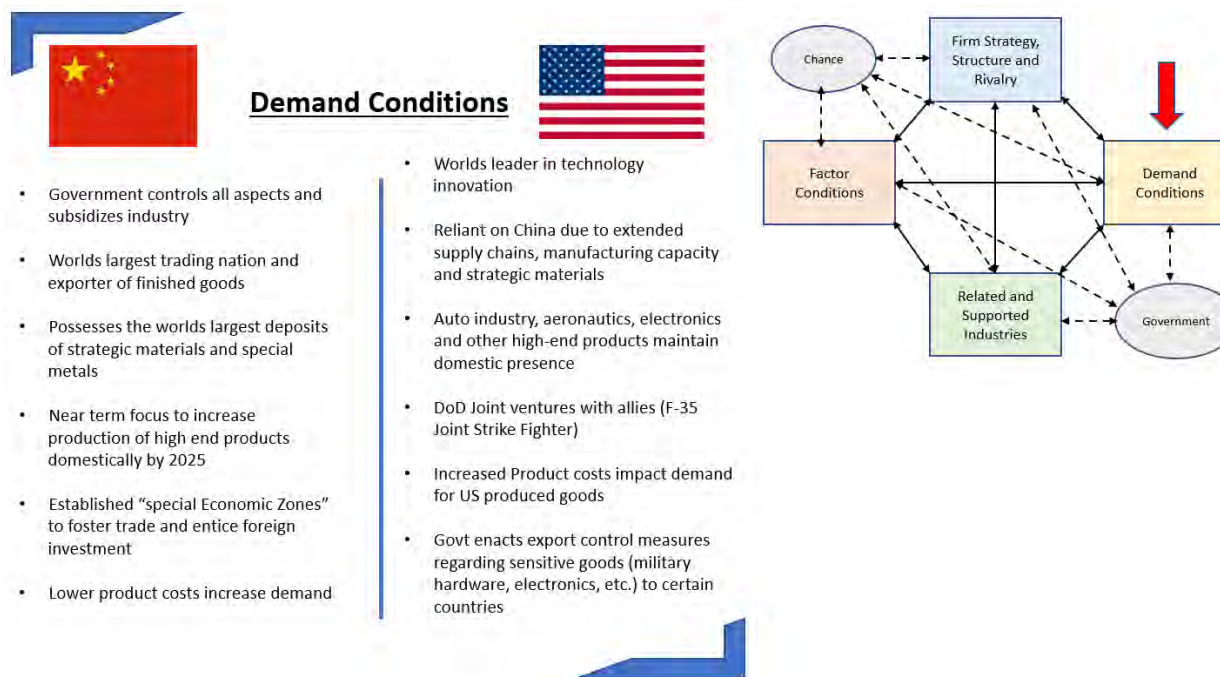


Figure 5: Porter’s Diamond Model - Demand Condition

APPENDIX-4

SWOT	China	Russia	United States
Strengths	<ul style="list-style-type: none"> • Made in China 2025 -Authoritarian Government: ability to control all economic sectors -Technology transfer -R&D Investments and clusters -Education investments in STEM • Loose state regulations* • Cheap labor* • Size of economy* • GDP growth (vice U.S.)* • Market position as “world’s factory”* <p>*areas trending downward</p>	<ul style="list-style-type: none"> • Interest in new industries, particularly in the IT market • World’s gas, oil, and mineral resources • Defense technology 	<ul style="list-style-type: none"> - Robust innovation sector - Academic research institutions - Availability of capital resources (market driven economy) - Intellectual property laws - IT infrastructure
Weaknesses	<ul style="list-style-type: none"> • Aging population • Authoritarian government: image issues, human rights issues, internal policies issues that impede competitiveness. • Data Policy - “Great Fire Wall” • Safety regulations • Need of market liberalization policies to foster domestic competition. 	<ul style="list-style-type: none"> • Concern automation/tech advances will increase job loss. • Ineffective ownership structure for cooperation of industrial enterprises • High cost of technologies development • Skilled labor supply • Low Investments in R&D and Public-Private partnerships • Not competitive: one of the least productive moderately rich countries in the world • “State capitalism” 	<ul style="list-style-type: none"> - Lack of coordinated industrial policy. - Reduced manufacturing output (market share) - undergrad STEM; career and tech education - Political & economic unpredictability (market driven economy) - Dependence on foreign natural resources - Declining support for R&D and capital investments.
Opportunities	<ul style="list-style-type: none"> • Underutilized rural population - potential for urban growth and increasing the service sector. • East Asia’s growing purchasing power. • Room to increase economic efficiency, productivity, and innovation through market liberalization 	<ul style="list-style-type: none"> • Given the interest, there is much room for growth in the nascent IT market 	<ul style="list-style-type: none"> - Creation of well-paying domestic jobs - Use of underutilized foreign labor/academic pool. - Automation - Legislative/executive branches’ current infrastructure & education investments
Threats	<ul style="list-style-type: none"> • China-U.S. trade war: sanctions, decrease in foreign demand. • Anti-globalization movements 	<ul style="list-style-type: none"> • Sanctions • Competition from other countries • Economy dependent on volatile oil, gas, natural resource market 	<ul style="list-style-type: none"> - Critical component supply chain fragility - Cyber threats to open-architecture IT networks

	<ul style="list-style-type: none"> • Competitor nations in low-tech manufacturing, e.g., India and Vietnam 		<ul style="list-style-type: none"> - Foreign work force development and job opportunities surpassing U.S. - IP Theft (p.25 of paper)
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Figure 6: Comparative Analysis of Strengths, Weaknesses, Opportunities, and Threats

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Fulfillment by Amazon from A to Z and
Everything in Between
Firm Brief Corporate Introduction

Mr. Douglas Babb, CAPT Eric Drey, CDR Dave Fuchs, & Lt Col Elia Hickie

UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

FORM 10-K

(Mark One)

ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934
For the fiscal year ended December 31, 2019

or

TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934
For the transition period from _____ to _____
Commission File No. 000-22513

AMAZON.COM, INC.
(Exact name of registrant as specified in its charter)

Delaware 91-1646860
(State or other jurisdiction of incorporation or organization) (U.S. Employer Identification No.)

410 Terry Avenue North
Seattle, Washington 98109-5210
(206) 266-1000
(Address and telephone number, including area code, of registrant's principal executive offices)

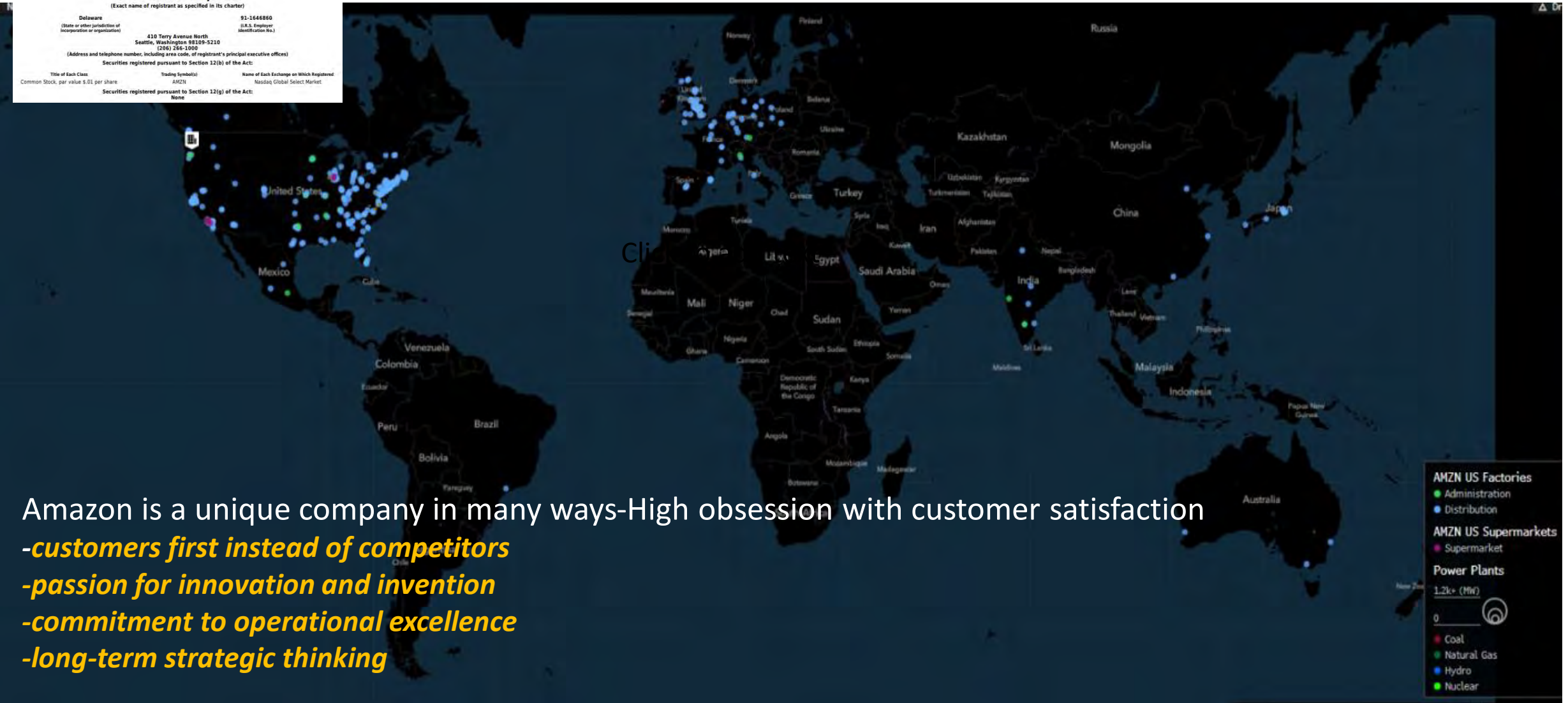
Securities registered pursuant to Section 12(b) of the Act:

Title of Each Class	Trading Symbol(s)	Name of Each Exchange on Which Registered
Common Stock, par value \$ 0.01 per share	AMZN	Nasdaq Global Select Market

Securities registered pursuant to Section 12(g) of the Act:
None

Amazon
Founded in the US in 1994 now
a global enterprise in 25 years

Revenue 386B
Employees 1.3M
Square Footage 458M (Leased) 20M (Owned)



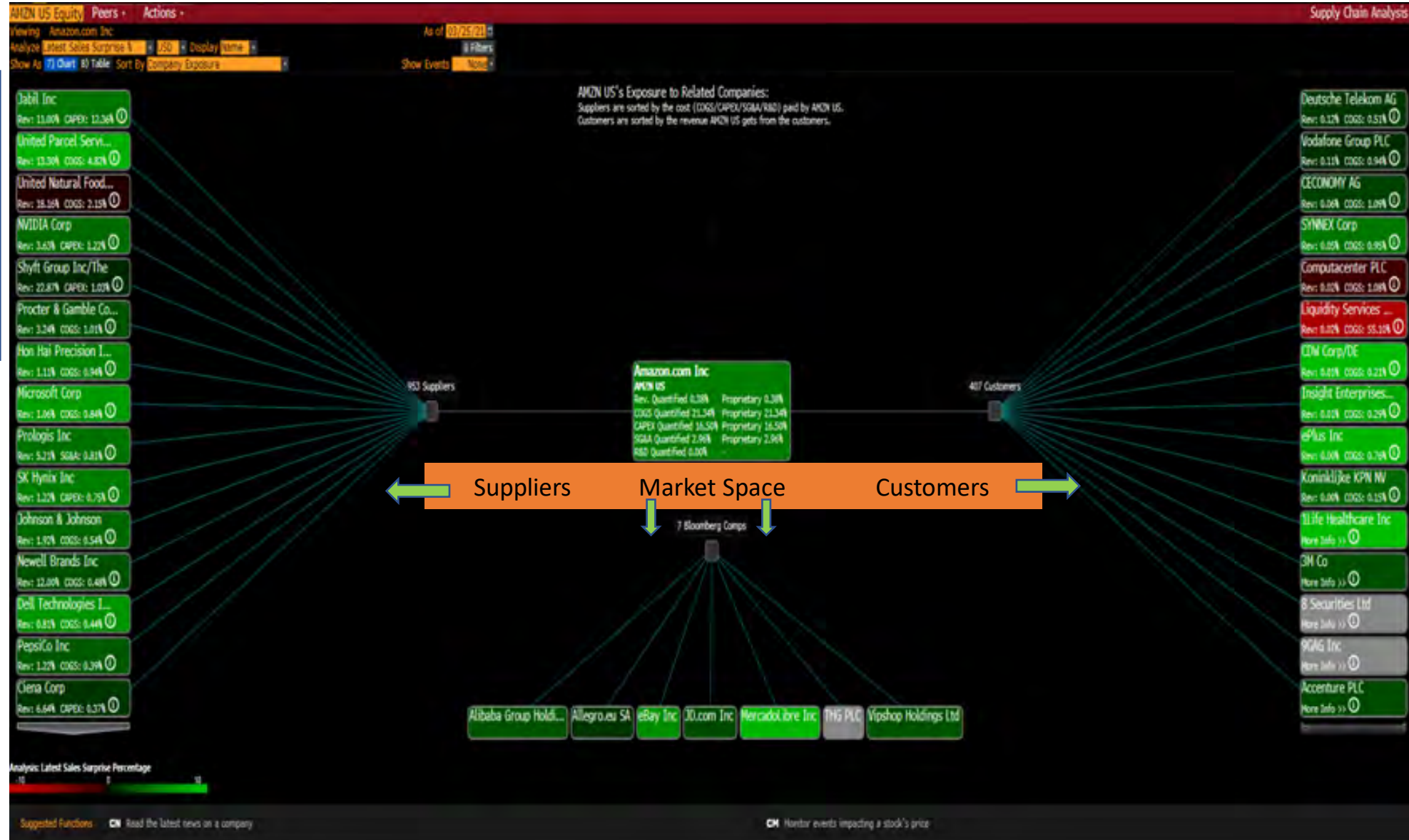
Amazon is a unique company in many ways-High obsession with customer satisfaction

- customers first instead of competitors
- passion for innovation and invention
- commitment to operational excellence
- long-term strategic thinking

A global e-Commerce Company requires a Global Supply Chain

953 Suppliers
407 Customers

7 related
industries/Competitors



Numbers Tell the Amazon Corporate Story....



Amazon Investments and Acquisitions

2011-2019 Acquisitions (60)

2011-LoveFilm (UK)	312M	2018-Ring (US)	839M
2012-Kiva Systems (US)	775M	-PillPack (US)	753M
Evi (UK)	26M	2019- CloudEndure (Is)	250M
2014-Twitch Interactive (US)	970M		
2015-Elemental Tech (US)	500M		
2017-Whole Foods (US)	13.7B		

Weighted Average Cost of Capital (WACC)-the minimum return a company must earn on its existing asset base to satisfy creditors, owners and investors.

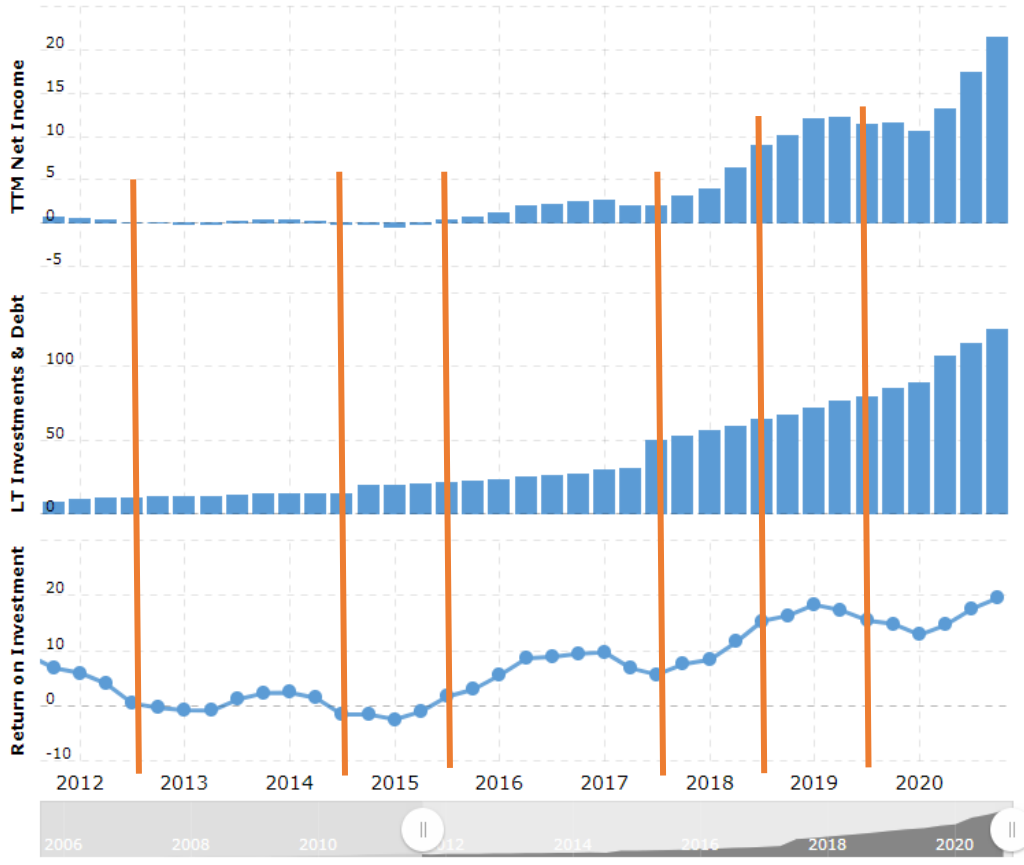
Return on Invested Capital (ROIC)- the amount of money a company makes that is above the the average cost it pays for its debt and equity capital. 2% or greater is creating value and less than 2% then destroying value.

Search for ticker or company name...

Compare AMZN With Other Stocks

From: 12/31/2011 To: 01/01/2021

Zoom: 1Y 2Y 3Y 5Y All



Amazon Corporate By Major Segment

AMZN US Equity 90 Actions * 97 Export * 90 Settings

Amazon.com Inc ASC 842 Periods 10 Annuals Cur FRC (USD)

Key Stats I/S B/S C/F Ratios Segments Addl ESG Custom

10 By Measure 13 By Geography 3 By Segment

In Millions of USD except Per Share

12 Months Ending	2011 Y 12/31/2011	2012 Y 12/31/2012	2013 Y 12/31/2013	2014 Y 12/31/2014	2015 Y 12/31/2015	2016 Y 12/31/2016	2017 Y 12/31/2017	2018 Y 12/31/2018	2019 Y 12/31/2019	2020 Y 12/31/2020
* Revenue	48,077.0 100.0%	61,093.0 100.0%	74,452.0 100.0%	88,988.0 100.0%	107,006.0 100.0%	135,987.0 100.0%	177,866.0 100.0%	232,887.0 100.0%	280,522.0 100.0%	386,064.0 100.0%
Online Stores	—	—	—	—	76,863.0 71.8%	91,431.0 67.2%	108,354.0 60.9%	122,987.0 52.8%	141,247.0 50.4%	197,346.0 51.1%
Third-Party Seller Services	—	—	—	—	16,086.0 15.0%	22,993.0 16.9%	31,881.0 17.9%	42,745.0 18.4%	53,762.0 19.2%	80,461.0 20.8%
AWS	—	—	3,108.0 4.2%	4,644.0 5.2%	7,880.0 7.4%	12,219.0 9.0%	17,459.0 9.8%	25,655.0 11.0%	35,026.0 12.5%	45,370.0 11.8%
Subscription Services	—	—	—	—	4,467.0 4.2%	6,394.0 4.7%	9,721.0 5.5%	14,168.0 6.1%	19,210.0 6.8%	25,207.0 6.5%
Other	—	—	—	—	1,710.0 1.6%	2,950.0 2.2%	4,653.0 2.6%	10,108.0 4.3%	14,085.0 5.0%	21,453.0 5.6%
Physical Stores	—	—	—	—	0.0	0.0	5,798.0 3.3%	17,224.0 7.4%	17,192.0 6.1%	16,227.0 4.2%
* Electronics & Other General Mer...	28,712.0 59.7%	38,628.0 63.2%	48,802.0 65.5%	60,886.0 68.4%	—	—	—	—	—	—
* Media	17,779.0 37.0%	19,942.0 32.6%	21,716.0 29.2%	22,505.0 25.3%	—	—	—	—	—	—
* Other	—	—	826.0 1.1%	953.0 1.1%	—	—	—	—	—	—
* Other	1,586.0 3.3%	2,523.0 4.1%	—	—	—	—	—	—	—	—
* Net Sales % Increased at Constan...	—	—	—	—	—	—	—	—	—	—
AWS	—	—	—	—	70.00	55.00	43.00	47.00	37.00	30.00
International	18.00	15.00	—	—	—	—	—	—	—	—
International	47.00	40.00	—	—	—	—	—	—	—	—
International	16.00	12.00	—	—	—	—	—	—	—	—
* Revenue Growth %	—	—	—	—	—	—	—	—	—	—
Other	—	—	—	—	—	72.51	57.72	117.24	39.34	52.31
Third-Party Seller Services	—	—	—	—	—	42.93	38.65	34.08	25.77	49.66
Online Stores	—	—	—	—	—	18.95	18.50	13.50	14.84	39.71
Subscription Services	—	—	—	—	—	43.13	52.03	45.75	35.58	31.21
AWS	—	—	—	49.00	70.00	55.00	43.00	47.00	37.00	30.00
Physical Stores	—	—	—	—	—	—	—	197.07	-0.18	-5.61
* Electronics & Other General Mer...	56.00	35.00	26.00	25.00	24.00	—	—	—	—	—
* Media	19.00	12.00	9.00	4.00	0.02	—	—	—	—	—
* Other	—	—	21.00	12.00	4.00	—	—	—	—	—
* Other	66.00	59.00	—	—	—	—	—	—	—	—
* Sales Change - Mix %	—	—	—	—	—	—	—	—	—	—
Electronics & Other General Mer...	60.00	63.00	—	—	—	—	—	—	—	—
Media	37.00	33.00	—	—	—	—	—	—	—	—
Other	3.00	4.00	—	—	—	—	—	—	—	—
AWS	—	—	4.00	5.00	7.00	—	—	—	—	—
* Total Square Feet/Meter	48,307.0 100.0%	73,081.0 100.0%	93,884.0 100.0%	113,719.0 100.0%	134,990.0 100.0%	179,345.0 100.0%	253,985.0 100.0%	288,419.0 100.0%	333,786.0 100.0%	458,224.0 100.0%
* Total Square Footage	48,307.0 100.0%	73,081.0 100.0%	93,884.0 100.0%	113,719.0 100.0%	134,990.0 100.0%	179,345.0 100.0%	253,985.0 100.0%	288,419.0 100.0%	333,786.0 100.0%	458,224.0 100.0%

Amazon Competitors By Segment and Future Trendlines



Online Stores



Subscription Services

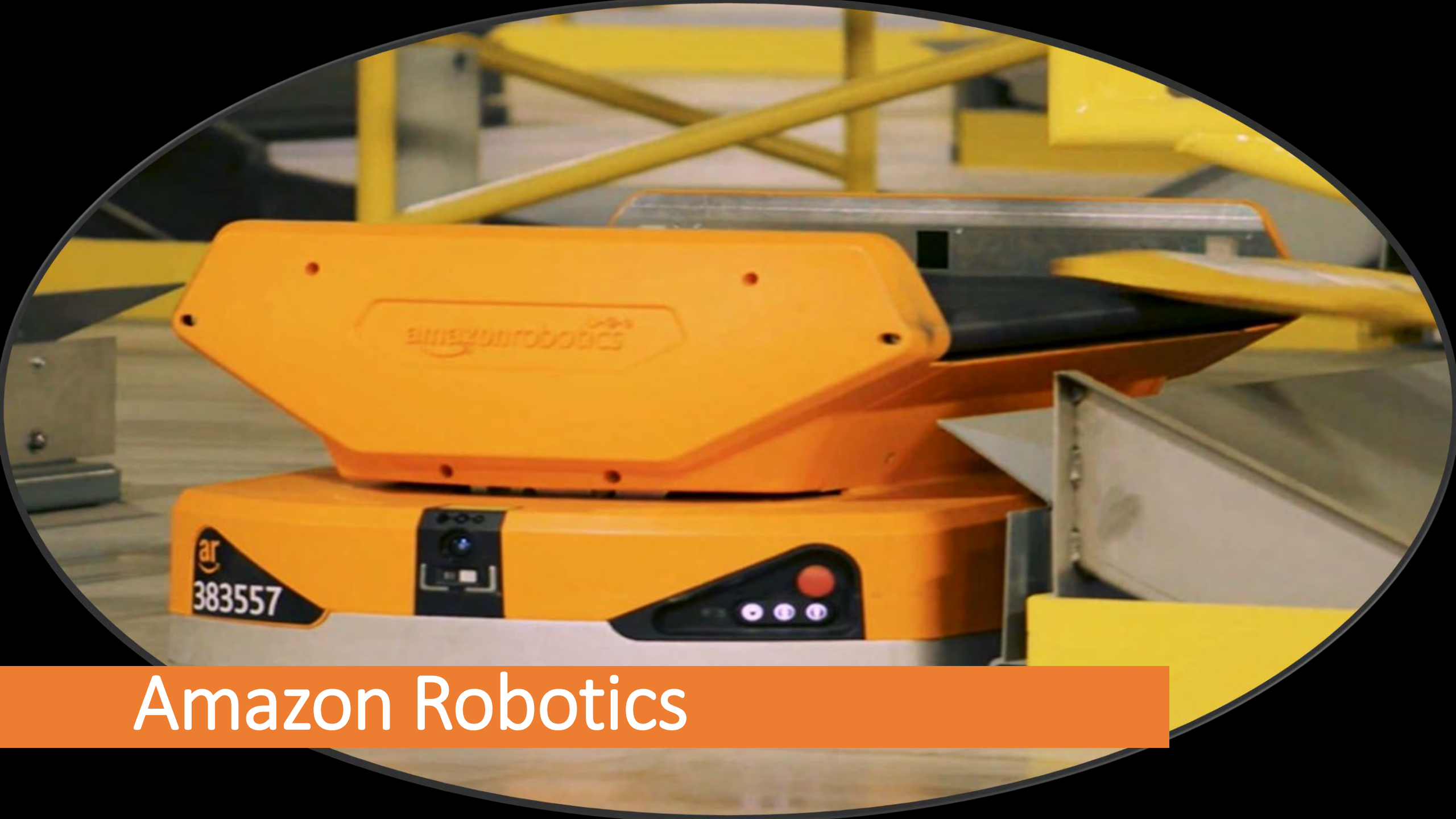


Grocery Stores



Cloud Infrastructure and storage





Amazon Robotics

We all know this guy....

- Started the company as an online bookseller in 1994 run out of his garage
- Has always maintained Amazon was "a technology company that simplified transactions for online consumers"
- Today Amazon is valued at \$1 Trillion
- Worth over \$180 Billion





Who is this guy?

Andy Jassy, will take over as CEO later this year

- Formerly the CEO of Amazon Web Services, Amazon's very profitable cloud business
- Big expensive shoes to fill.
- Facing challenges on maintaining market share, continuing to modernize, antitrust issues and the threat of unionization

The Amazon logo, featuring the word "amazon" in a bold, black, lowercase sans-serif font. Below the text is a curved orange arrow that starts under the letter 'a' and points to the right, ending under the letter 'n'. The logo is centered within a white rectangular area.

What is Amazon Robotics

- Origins and Acquisitions (location, size, history)
- The Market
- Customers
- The Potential..
- The “click to ship” cycle used to be around 60-75 minutes when employees had manually to sift through the stacks, pick the product, pack it, and ship it. Now, robots handle the same job in 15 minutes, according to a Deutsche Bank note published Tuesday (June 14) based on Amazon’s metrics.



Origins and Acquisitions

- Robotics (Amazon as a consumer, not supplier)
- Amazon purchased Kiva Systems in 2012
 - \$775 Million
- Amazon has invested \$100 Billion into R&D
 - Large focus on warehouse automation and efficiency
 - Also includes self-driving deliveries and drones
 - Currently have 20,000 delivery vans, 500 semi-trucks and 50 airplanes
- In 2015 Kiva Systems renamed Amazon Robotics
- Amazon has over 200,000 Robots today
- Streamlined warehouse procedures and driven down cost
- In 2019 Amazon purchased Canvas Technologies
 - Another Robotics Start Up out of Boulder, CO
- Robotic Automation has allowed Amazon to reduce physical labor, decrease stock "mis-sorts" by 50%, increase safety, speed, and efficiency
- Amazon acquired ZOOX in June 2020 for \$1.3 Billion
 - Self-Driving Taxi is valued at \$1 Trillion, expected to hit \$9 Trillion by 2029
- Amazon will open its new \$40 Million Robotics Innovation Hub in 2021 (outside of Boston, MA)





Key Characteristics

- The “click to ship” cycle used to be around 60-75 minutes when employees had manually to sift through the stacks, pick the product, pack it, and ship it. Now, robots handle the same job in 15 minutes.
- Competitors are also automating (Walmart.com, Alibaba) their factories
- Stiff competition with drones (UPS has FAA certification, FEDEX first drone delivery in 2019, DHL has already teamed with a Chinese Drone manufacturer)
- The Global robotics market is expected to reach \$42 Billion in 2026
- Amazon is unique due to acquisition strategy for warehouse automation
 - Will buy suppliers if the company can potentially improve efficiency
- Currently this is a commercial market potential DoD use down the road (DLA, USTRANSCOM)
- Limited number of sellers
 - Mostly Japanese companies, a few European
- Global industrial Robotics Market expected to reach \$26 Billion by 2026
- Amazon is developing its own technology through its Robotics Innovation Hub
- No formal Rules to this market but any success Amazon has will be emulated

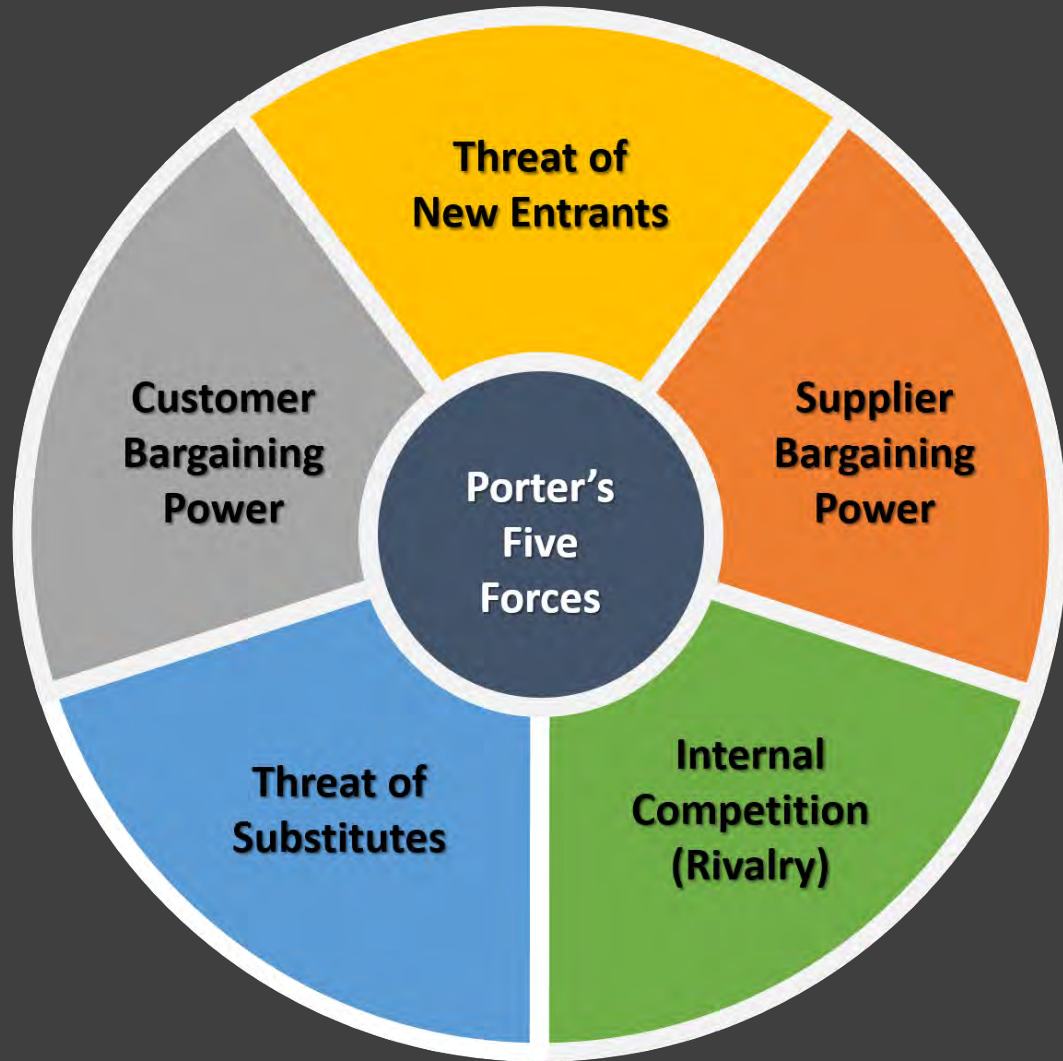


Largest Industrial Robot Manufacturers

1. ABB Groups (Switzerland/Sweden)
2. Yaskawa Electric Corp (Japan)
3. KUKA - Midea Group (China)
4. FANUC Corp (Japan)
5. Kawasaki (Japan)
6. Epson Robots (Japan)
7. Staubli (Switzerland)
8. Nachi-Fujikoshi Corp (Japan)
9. Comau (Italy)
10. Omron-Adept (Japan)

U.S. Robotics Firms sold to Foreign Firms

- Boston Dynamics to South Korea's Hyundai (2020)
- Kindred and Haddington Dynamics to U.K.'s Ocado (2020)
- JR Automation to Japan's Hitachi (2019)
- Torc Robotics to Germany's Daimler (2019)
- Paslin to China's Zhejiang Wanfeng Tech Co (2016)
- Adept Technology to Japan's Omron (2015)
- RobotWorx to New Zealand's Scott Technology (2014)
- Unimation to Switzerland's Staubli (1989)



Market Structure (Porter's Five Forces)

- Amazon Robotics is not a business
 - Former Customers: Staples, Walgreens, Zappos, Gap, Office Depot, Crate and Barrel, the Gifte Group
 - 100,000 bots in 2015 – over 200,000 today
 - \$40M Innovation hub opened in 2020
- What is the Market?
 - Not Industrial Automation or E-Commerce
 - Logistics Automation: Kiva Robotics, Scout Robots, Delivery Drones, Zoox self-driving Vehicles, BALYO self-driving materials handling, and Aurora self-driving semi-trucks



Rivalry among Competitors & New Market Entrants

- There are no peer competitors...
- New entrants (warehouse market):
 - Locus – robot "pickers"
 - \$1 billion valuation
 - 4,000 robots
 - 40 customers: DHS, Boots
 - Fetch Robotics – Pallet Conveyors & Pickers
 - \$221 million valuation
 - GreyOrange (India)
 - \$700 million valuation



Nature of Competition

- Strategy in each market to maximize profitability
 - E-commerce
 - Industrial Robotics (17% growth)
 - Warehouse Automation (12% growth)
- Key means of pursuing strategy: M&A and R&D
- Distinct activities relevant to strategy
 - Systematic Cost Reduction
 - Increased efficiency
 - Lower labor costs
- Type of innovations at the firm: Better Technology
- Approach to Industry Change: Stay Ahead

Bargaining Power of Suppliers

- Potential Supply Chain vulnerabilities
 - R&D in-house
 - Manages its own production facility
 - Based in Boston, MA
- Human Capital Challenges
 - Robotics Education 'Hub'
 - Large population center
 - International recruitment
 - Early Education Programs
 - Government partnerships



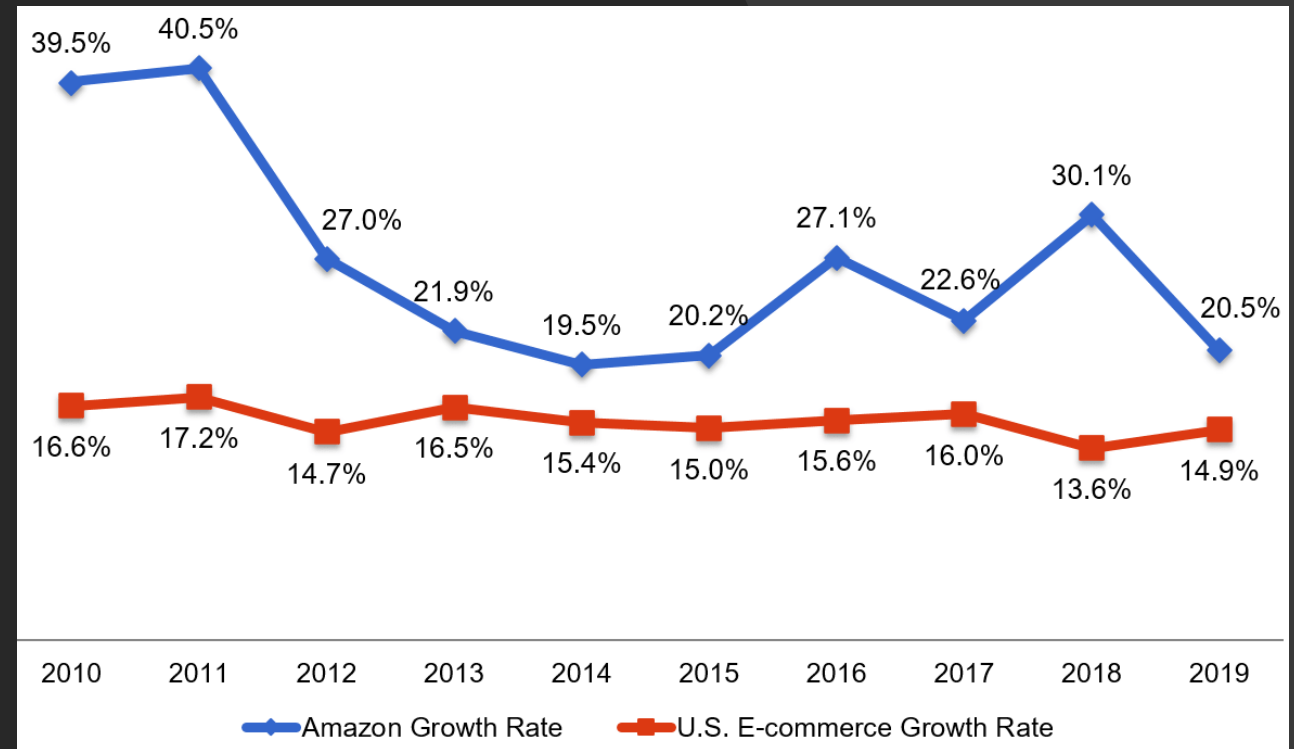


Bargaining Power of Buyers and the Threat of Substitutes

- This is a seller's market:
- The sale of Kiva created a market void
- Locus forecasts tenfold growth over several years
- Switching Costs for Buyers
- Less than 5% of the market is automated
- The market is being driven by productivity gains
 - 2-3 times the productivity
 - nearly 100% accuracy
- Local labor market with determine ROI

Secrecy as a Strategy

- A Skunkworks innovation model
- Amazon Robotics had a monopoly for Five Years
 - At least five year advantage over competition
 - Could enter the warehouse market with an ultra-premium product
 - 50% improvement of the Kiva bots
 - Advantages in experience, funding, R&D, & infrastructure
- With Amazon's absence, warehouse logistics market trending to monopolistic competition
- Is the Amazon Robotics creating value at an acceptable level of financial risk?
 - Deutsche Bank – Savings of \$22M per FC
 - Potential \$2.5 Billion savings or 20% of operating income
 - \$15 billion in NPV from \$775 million Kiva investment





Policies, Surging and Mobilization

Advanced Manufacturing

Amazon's Recent DoD Contract Experience

- Oct 2017: DoD Request for Information
- Dec 2017: Defense Forum
- Oct 2019: Microsoft announced for contract



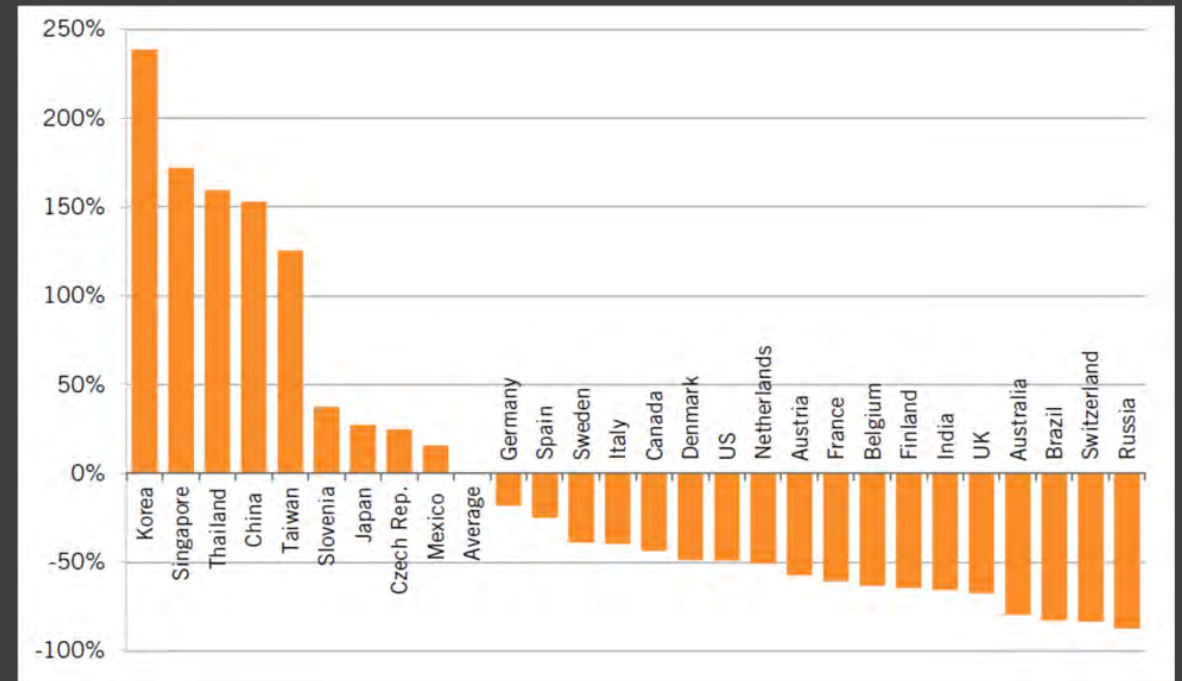
Products relevant to National Security

- "Smart" Warehouses
 - Kiva robots
 - Robotic arms
- Drones
 - Quad/Multi-Copters
 - Rovers
- Automated vehicles
 - Zoox personnel carriers
 - Aurora partnership



The U.S.
Trails its
Competitors

Robotic Adoption Rate as a Share
of Expected Adoption Rate





Surging

- Core expertise in Warehouse Robots
 - Expand Kiva production to 100%
 - Utilize existing suppliers to the greatest extent possible
- Expectations: limited supplies of electronic circuit boards, chips, industrial robots, machine tools and most hardware
- Engineer or ID new sources of supply
- Continue development of other robotic systems

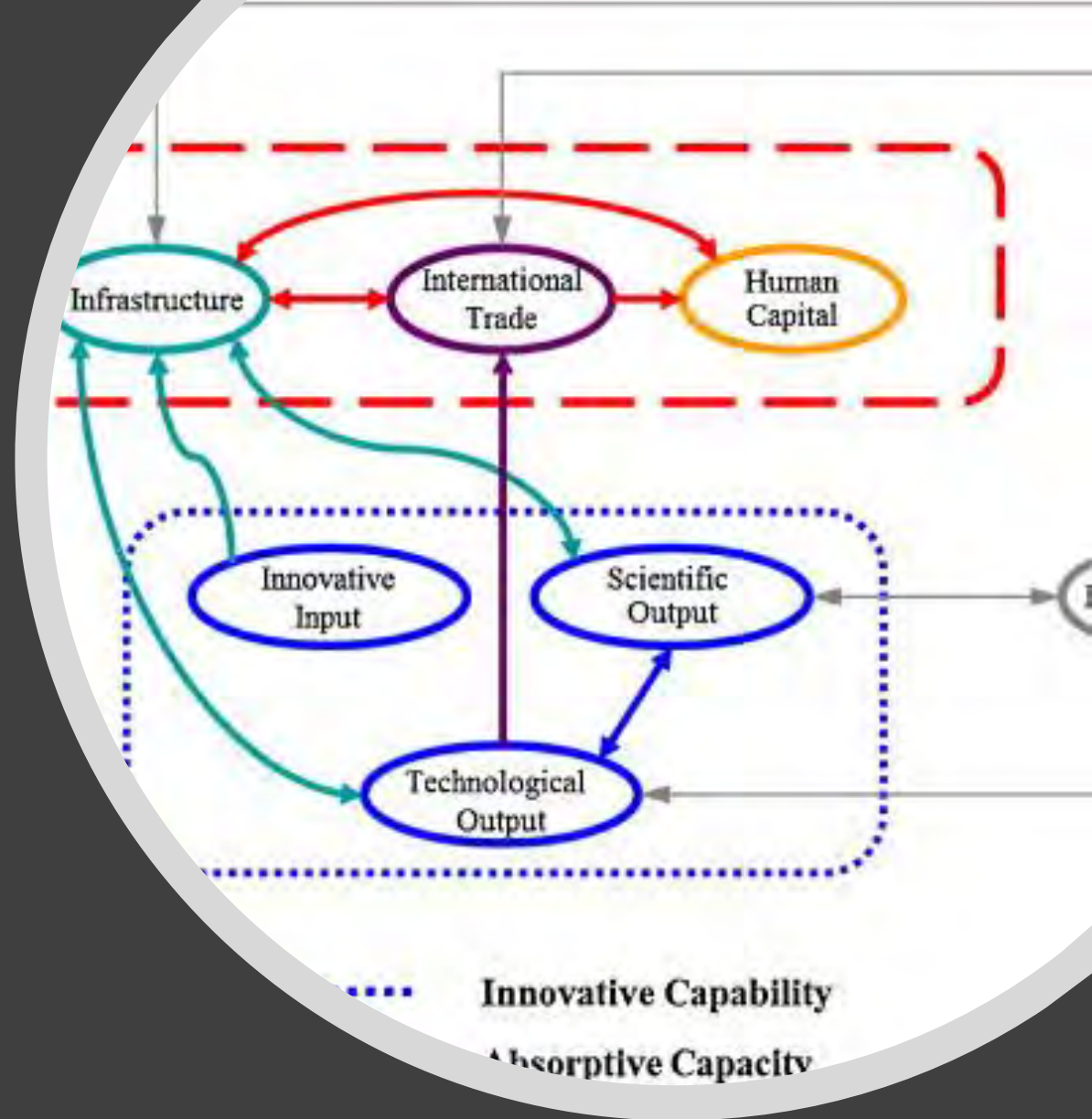
Mobilizing

- Expand production capacity
 - Robotic arms
 - Needs of Amazon and Industry
 - Quad/multi-copters
 - Dual use



National Innovation System Dynamics and Priorities

- A strong national innovation system has balanced sides
 - Business environment
 - Regulatory environment
 - Innovation policy environment
- US has two strong sides with a weak innovation policy environment





Disruptive Technology

- Amazon robotic facts: robots make work easier, process orders faster, do not replace employees, can lift 340 kg/750 lbs
- Automation is disrupting multiple types of manufacturing
 - Human and machine collaboration
 - Reduce time required to process an average order
 - Lower production lead times and less bottlenecks
 - Automotive: just-in-time production
 - Aviation: augment dangerous conditions
 - Electronics manufacturing: higher precision



Implication for Corporate Strategies

Amazon's four guiding principles:

- Customer Obsession
- Passion for Invention
- Operational Excellence
- Long-Term Thinking

Great Power Competition

- 2018 robot installation comparison (International Federation of Robots)
 - China: 154,000
 - Japan: 55,200
 - US: 40,000
- China has vast subsidies for robots
 - Responsible for 44% of net profits for 53 listed companies in 2018
- Motivation to help offset aging population
- China retains lead as world's largest industrial robot market





Defense Readiness

Security concerns

Ethics



- Artificial Intelligence
- Decision making
 - Kill authority
 - Decide if lethal force necessary



Conclusion

- Amazon capable of meeting U.S. National Security needs
- Relationship is instrumental to reinforcing national innovation system

amazon



Questions?

amazon robotics

amazon robo

amazon robotics

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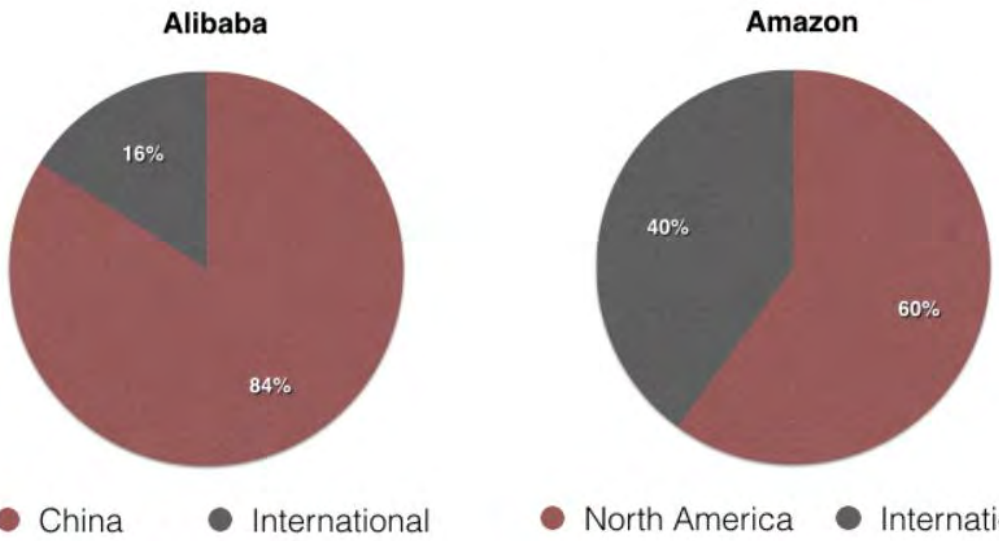
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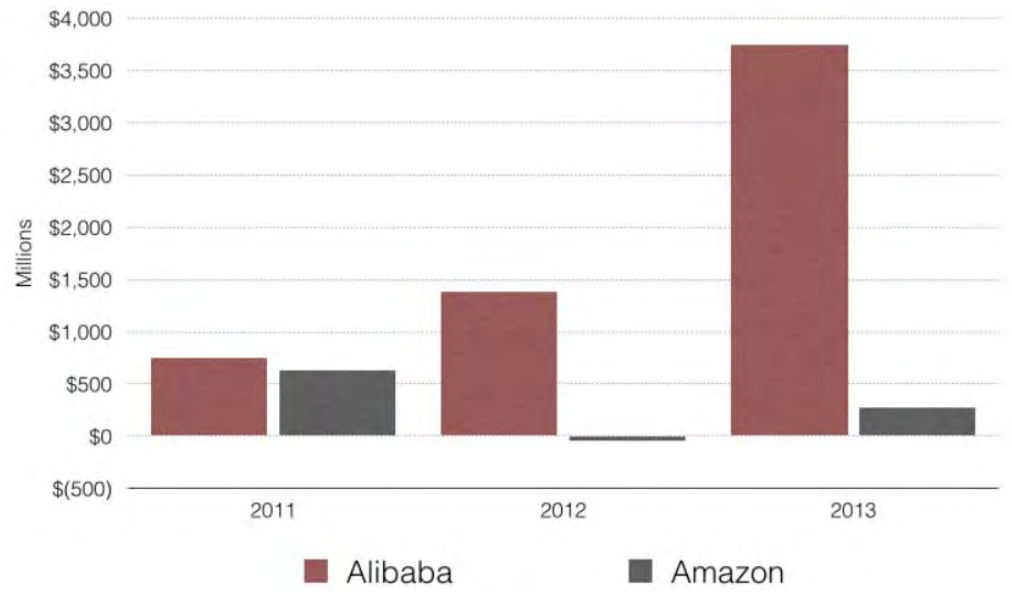
You can see more Trefis technology company data here.



[Is Alibaba Really The Amazon Of China? \(forbes.com\)](https://www.forbes.com)



Annual Profits



[Alibaba vs. Amazon: An In-Depth Comparison of Two eCommerce Giants \(ecommercefuel.com\)](https://ecommercefuel.com)

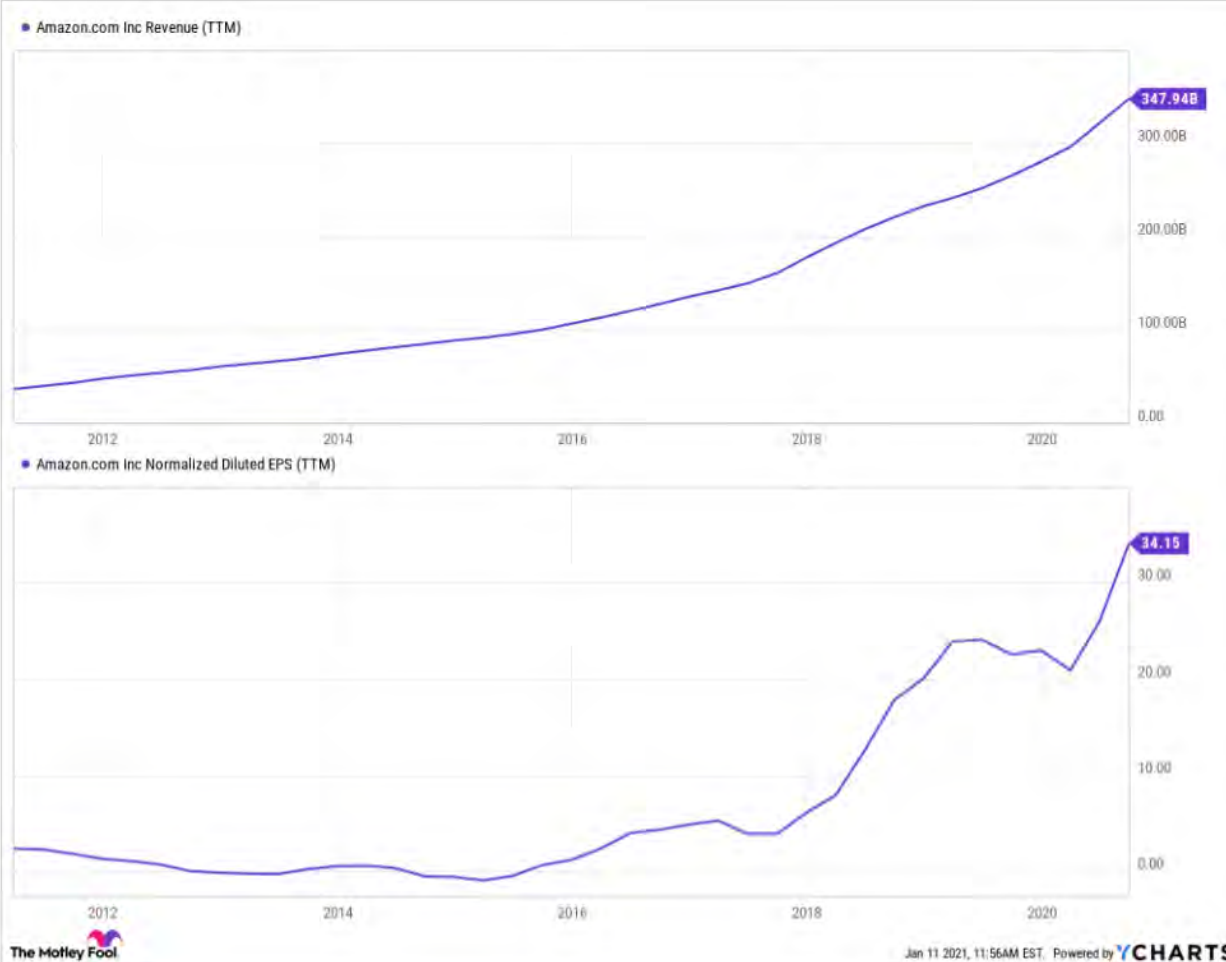
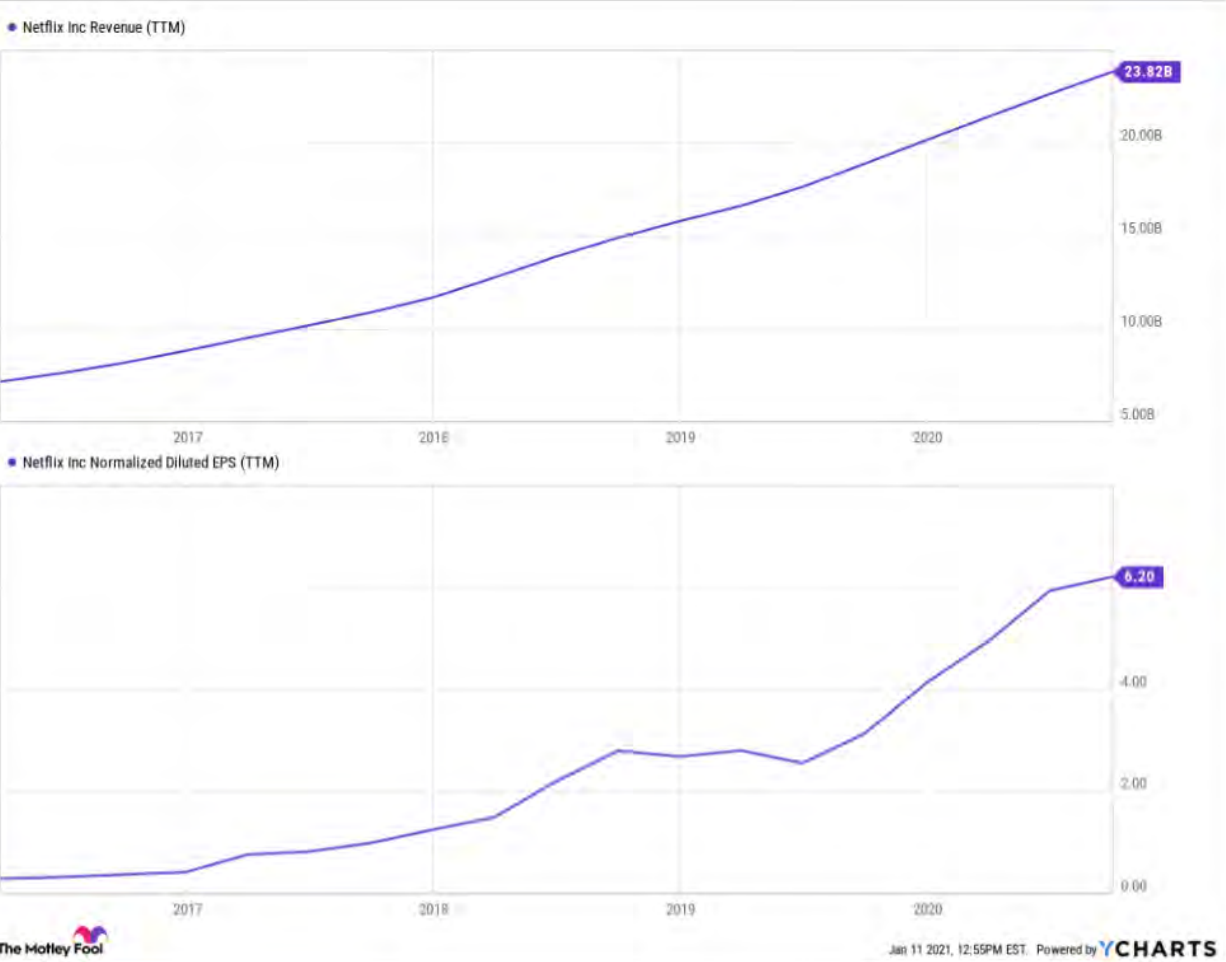
[Alibaba vs. Amazon: An In-Depth Comparison of Two eCommerce Giants \(ecommercefuel.com\)](https://ecommercefuel.com)

Not Apples to Apples But Plenty of Market Share and room to grow



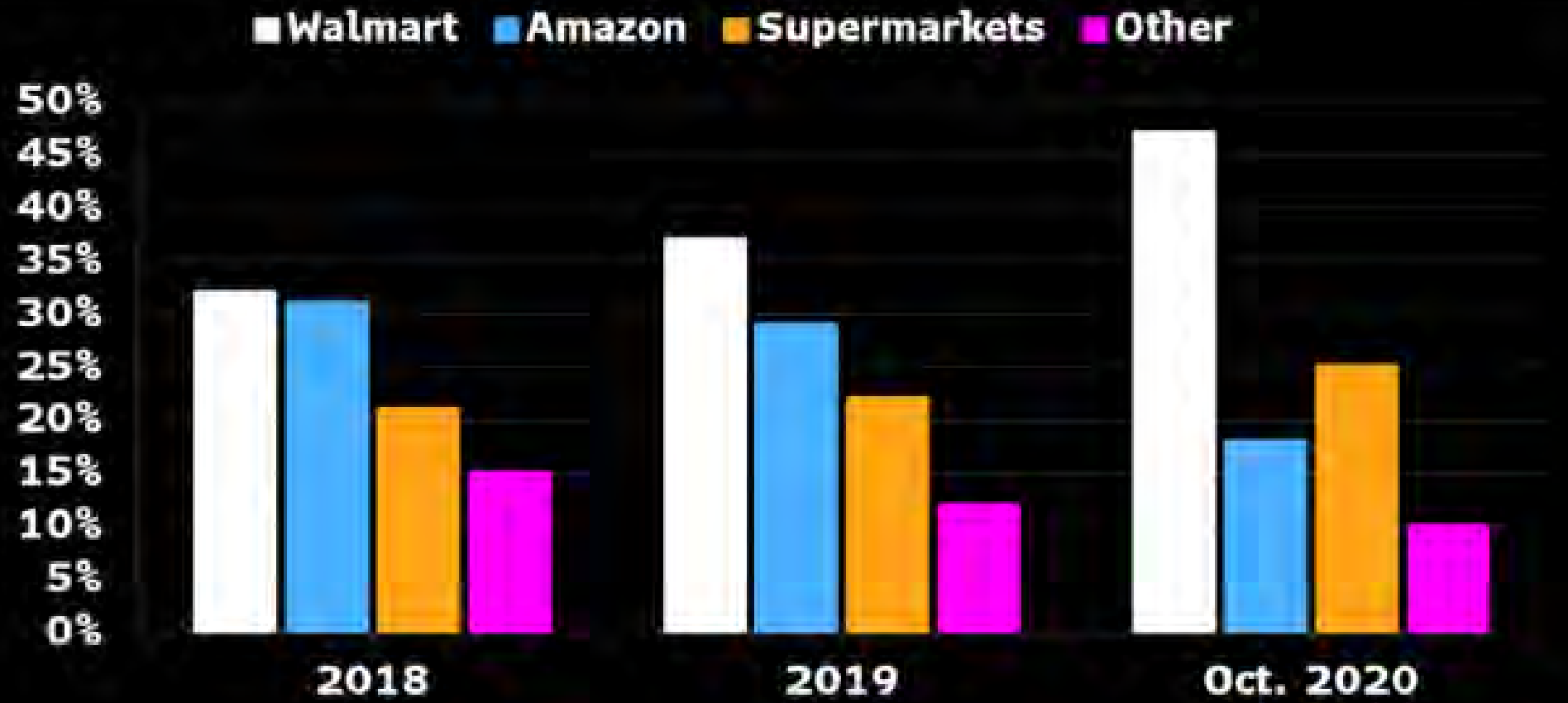
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amazon





Grocery Segment at a Glance



Bloomberg

Source: Retail Feedback Group U.S. Online & In-Store Grocery Shopping Study, 2020

Exhibit



Poised to make a move in the Big Data Sector

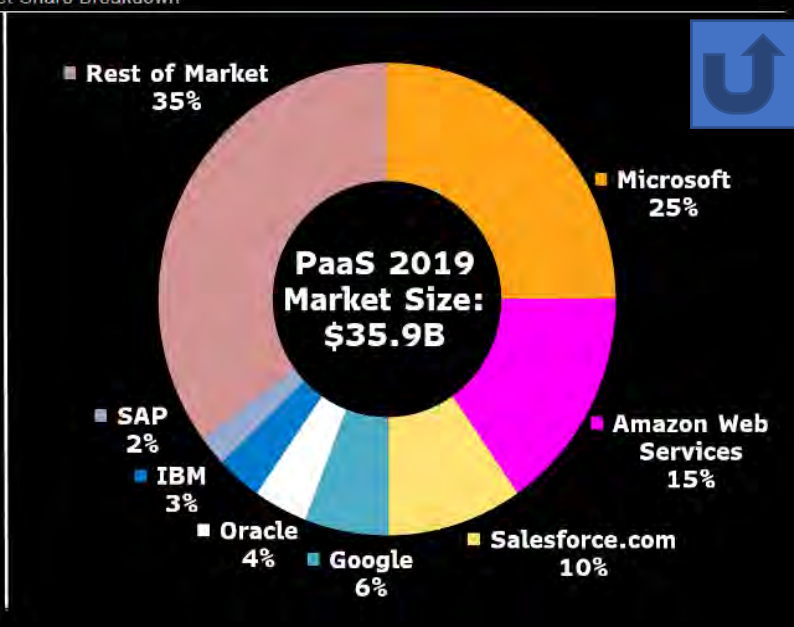
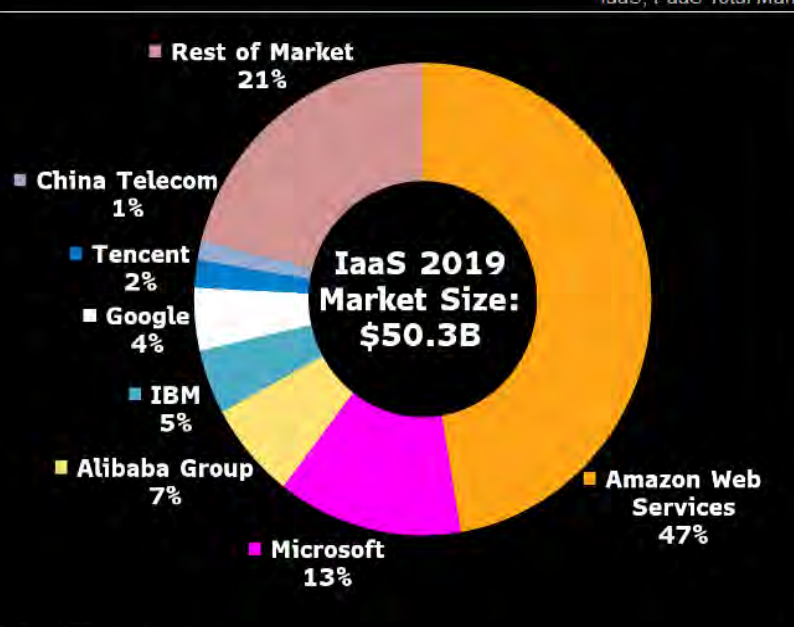
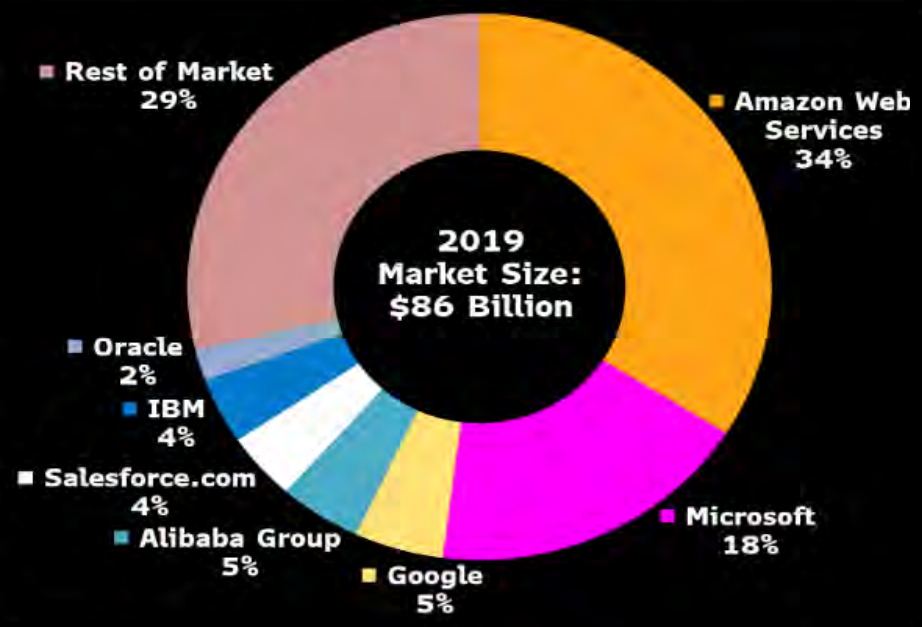
Data storage, Infrastructure, analytics, AI



	2017 Market Share (%)	2019 Market Share (%)	Market Share Change (%)
Oracle	42.3%	36.5%	-5.8%
Microsoft	24.3%	29.1%	4.8%
IBM	12.7%	11.4%	-1.3%
SAP	7.4%	7.0%	-0.4%
Amazon Web Services	2.9%	4.8%	1.9%
Teradata	3.0%	2.4%	-0.6%
Alibaba Group	0.2%	0.8%	0.6%
Fujitsu	0.6%	0.6%	0.0%
Rest of Market	6.7%	7.4%	0.7%

Source: IDC, Bloomberg Intelligence

Exhibit



Source: IDC, Bloomberg Intelligence

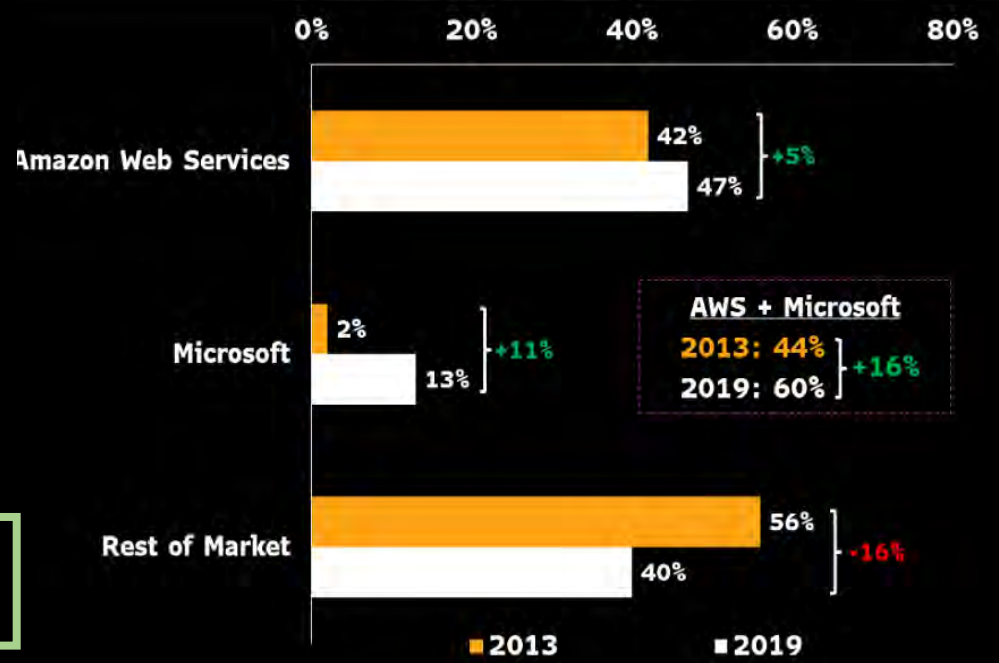
AWS, Microsoft IaaS Market-Share Expansion

6. Why Growth May Top 25% for Next Two Years

Contributing Analysts [Anurag Rana](#) (Technology) & [Sonak Kolar](#) (Technology)

Looking at the large untapped opportunity, we see no reason why Amazon Web Services couldn't increase sales over 25% annually for at least two years and about 20% for the next three. The public cloud infrastructure market -- Infrastructure-as-a-Service (IaaS) plus Platform-as-a-Service (PaaS) -- is less than \$100 billion vs. total enterprise tech spending of over \$1 trillion (and growing), supporting our thesis on AWS' rapid revenue pace. This market was \$86 billion at the end of 2019, with Amazon at No. 1 with 34% market share, based on IDC data. In IaaS alone, its share remained over 47% in the past four years even with stiffer competition from Microsoft and Google.

Despite leading in the space, AWS has expanded faster than the overall market in the past three years, with sales growth averaging 38%. (02/26/21)



Ending With Invigorated U.S. FTC

on) & [Sophia Isani](#) (Litigation)

considerable and varied. An emboldened FTC, in the midst of an investigation of the e-commerce giant, may sue and pursue divestitures, as could some U.S. states. Future sequential legislative proposals have solid chances of becoming new laws, and a tougher environment for M&A is also likely. (03/29/21)

Probes, Lawsuits, Antitrust Reform

on) & [Sophia Isani](#) (Litigation)

near- and long-term and come from the FTC's investigation, state probes, private lawsuits, potential new laws and a likely more-interventionist FTC. Possible government actions are the biggest risks. While months ago we were skeptical that the FTC would file a suit, the antitrust leadership taking shape under President Joe Biden has changed that, and government suits are more likely than private suits to culminate in manageable financial settlements. These risks are all long-term. Nearer-term threats include greater government intervention and a reshaped FTC.

Commissioner seats, flipping the FTC to 3-2 majority Democrat. Law professor Lina Khan, an Amazon critic, has been nominated. (03/29/21)

Keyly at Reshaped FTC

on) & [Sophia Isani](#) (Litigation)

Underway, the FTC's makeup is changing, increasing the chances of an eventual lawsuit against the company, as well as the potential for government intervention in our view. While we don't yet know who will be chairperson, the views of acting chair Rebecca Slaughter and newly appointed commissioners, are known. Both support aggressive, interventionist antitrust enforcement. Khan is a critic of Amazon, having argued that Amazon is a natural monopolist that should be broken up. FTC actions require a majority vote, and the two current Republicans are unlikely to be reappointed. A new chair could have the swing vote. Biden's antitrust placements have thus far been progressives.

likely be leaving as he's been named to lead the CFPB. (03/29/21)

Sta

Trump-Appointed FTC

Rebecca Slaughter, Current

Rohit Chopra

Noah Phillips

Christine Wilson

Joe Simons, Former Chair

23. New Laws May Be Bigger Long-Term Threat Than Court

Contributing Analysts [Jennifer Rie](#) (Litigation) & [Sophia Isani](#) (Litigation)

Antitrust legislation could have a greater impact than lawsuits, which are slow and face defendant-friendly precedent. Bipartisan interest in antitrust reform increases the likelihood of new laws, despite a closely divided Senate. Given the need for GOP votes, we believe that any bills will have to be watered down to pass, losing the most-intrusive measures. Still, current and expected bills are forbidding – Sen. Amy Klobuchar sponsored one that would ease plaintiffs' path in court and raise hurdles to M&A. The House antitrust panel's chair plans to introduce multiple bills in 1H based on a 3Q report by his majority staff. Likely provisions include a ban on operating a platform and competing on it (business separation), presumptive prohibitions against M&A, and bans on self-preferencing and most-favored-nation-type terms. (03/29/21)

Bloomberg and Bloomberg Law News:

- [Klobuchar Pushes Broad Antitrust Revamp As Hawley Targets Tech](#)
- [ANALYSIS: Is Antitrust Litigation at a Crossroads in 2021?](#)

24. Lawsuits to Be Long, Hard, Unpredictable Legal Fights

Contributing Analysts [Jennifer Rie](#) (Litigation) & [Sophia Isani](#) (Litigation)

Monopolization lawsuits against Amazon, both private and government, face an uphill climb based on current U.S. legal precedent. This is particularly true given that Amazon's low prices are arguably good for consumers. Liability outcomes on these suits are impossible to predict at this stage – monopolization cases are highly fact-intensive, require significant economic analysis, and entail the difficult balancing act of asking a court to weigh proven harmful effects of the targeted conduct against proven legitimate justifications. Still, it will likely be years before the suits are resolved, and even if liability is found, a conduct remedy is more likely than a structural one.

Allegations in Consumer Class Action Over Marketplace Fees and Restraints:

- Prohibitions on 3rd-party sellers from selling at lower price on other platforms
- Amazon's increasing fees give it a competitive advantage over 3rd-party sellers, both on and off Amazon's platform

Allegations in Consumer Class Action Over eBook Fees and Restraints:

- Contractual restraints imposed on the five major U.S. publishers inhibit other eBook retailers from competing on price
- Amazon increases eBook prices by tying its distribution services with its advertising services

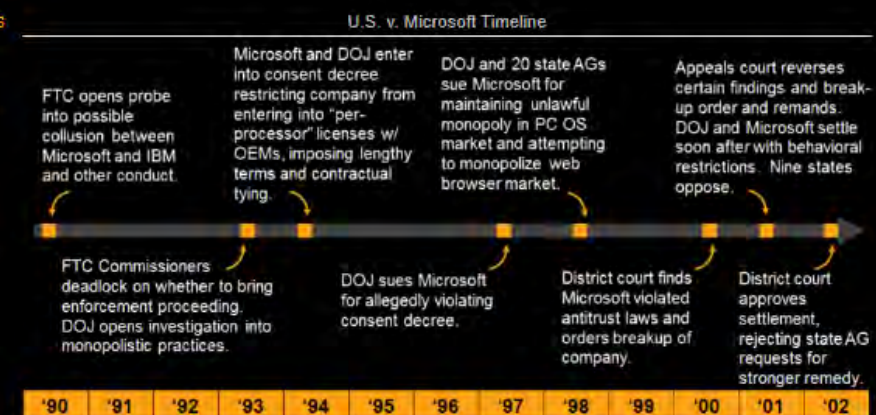
The ongoing consumer lawsuits against Amazon contain both monopolization and conspiracy claims, and concern pricing restrictions on certain products. (03/29/21)

25. Remedy That Includes Forced Break-Up Unlikely

Contributing Analysts [Jennifer Rie](#) (Litigation) & [Sophia Isani](#) (Litigation)

Assuming that U.S. antitrust enforcers or private plaintiffs proved in court that Amazon illegally monopolized or attempted to monopolize a market, a forced breakup is unlikely, particularly given that this could eliminate efficiencies that benefit consumers. Behavioral measures are more likely, such as removal of MFN clauses in contracts, firewalls between Marketplace and Basics, prohibitions on disadvantaging third-party sellers, and other conduct measures.

After years of litigation and a 2001 ruling that Microsoft unlawfully maintained its operating-system monopoly by excluding nascent competitors, the company wasn't split apart. Instead, it was barred from engaging in certain conduct and required to share API data with third-parties. It's widely believed that these measures were sufficient to restore healthy competition. (03/26/21)



Source: Bloomberg Intelligence

Exhibit

26. Some Conduct More Susceptible to Successful Challenge

Contributing Analysts [Jennifer Rie](#) (Litigation) & [Sophia Isani](#) (Litigation)

Among the various stratagems used by Amazon that have been deemed anticompetitive by politicians and critics, the most vulnerable to successful antitrust challenge, in our view, are pricing provisions that essentially prevent sellers from offering lower prices outside of Amazon.com. This type of conduct forms the basis for the consumer suits, one of which concerns multiple products and the other agreements with publishers for the sale of e-books. These policies allegedly have price-raising effects, costing consumers billions of dollars.

Affirming a finding that Apple unlawfully conspired to raise e-book prices in 2015, an appellate court noted that "most-favored-nation" clauses imposed on publishers were anticompetitive in that they were used to insulate Apple from price competition. (03/29/21)

27. Some Criticisms of Amazon Tougher to Label Anticompetitive

Contributing Analysts [Jennifer Rie](#) (Litigation) & [Sophia Isani](#) (Litigation)

Amazon's bundling of services via Prime, its practice of charging sellers more for FBA logistics services if the order is placed on a rival website, and allegations of below-cost pricing have a more tenuous path to antitrust liability than other conduct, in our view. Though each of these practices can be deemed anticompetitive, the bar is high for proving illegality, particularly if lower prices and other efficiencies result. Even if there is some harm shown, valid business reasons for the conduct can insulate Amazon from antitrust liability under U.S. antitrust laws.

Apple in 2014 defeated charges that it was attempting to monopolize a digital music market via iTunes software updates that hindered music sold by rivals from operating on iPods. The updates were deemed lawful because they provided product improvements. (03/29/21)

28. Predatory Pricing Near Impossible to Prove in Court

Contributing Analysts [Jennifer Rie](#) (Litigation) & [Sophia Isani](#) (Litigation)

Some critics of Amazon claim the ecommerce giant is guilty of predatory pricing in violation of the antitrust laws, such as selling products at prices below cost to drive out competition. Any lawsuit on this basis is unlikely to succeed. Plaintiffs would have to show that pricing is actually below cost and that any losses will later be recouped after rivals are eliminated. Both are difficult to prove. Courts are also cautious about issuing judgments that could result in deterring low prices that benefit consumers.

In relation to its 2012 lawsuit against Apple over price-fixing of e-books, the Justice Department disclosed that it examined and found "persuasive evidence lacking" that Amazon engaged in unlawful predatory pricing, noting that loss-leading and deep discounting are "to be celebrated, not outlawed." (03/28/21)

Court Filing

"The MFN played a pivotal role in this quid pro quo by 'stiffen[ing] the spines of the [publishers] to ensure that they would demand new terms from Amazon,' and protecting Apple from retail price competition."

U.S. Court of Appeals for the Second Circuit - Opinion, U.S. v. Apple
BLAW, June 30, 2015

[Click to view entire document](#)

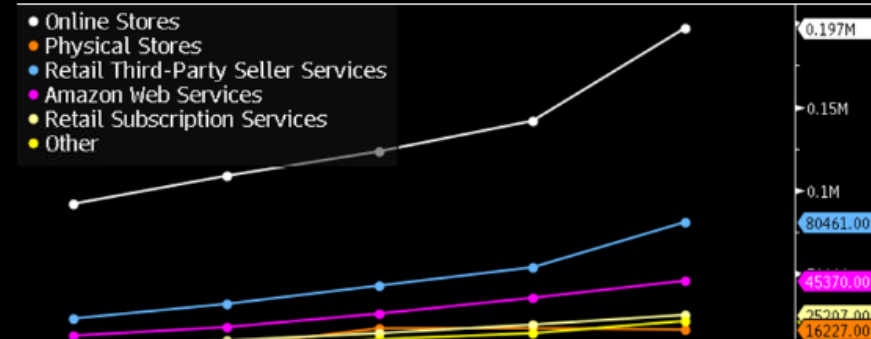
Company Filing

"In 2019, we invested more than \$15 billion in infrastructure, programs and people and added 225 new tools and services to help our sellers grow their brands and businesses. In addition, we invested billions more to expand one-day delivery to millions of products offered by Fulfillment by Amazon sellers and these investments are working. Sellers around the world are seeing success."

Britan Olsavsky, Amazon CFO - Annual Shareholder Meeting
May 27, 2020

[Click to view entire filing](#)

Amazon Net Sales by Product Group



GENERAL ELECTRIC (GE) FIRM BRIEF

PRESENTED BY:

NICHELE MESSIAH MUÑOZ

ELEANOR TANPIENGO

ALFREDO MONTELONGO



GE OVERVIEW

- PROFILE
- FINANCIALS
- THE STORY
- OVERALL FIRM STRATEGY
- PORTERS DIAMOND
- AVIATION SEGMENT
- PORTERS FIVE FORCES
- STRATEGY FOR MAXIMIZING PROFIT
- INNOVATION & ETHICS
- HUMAN CAPITAL CHALLENGES
- FUTURE OF GENERAL ELECTRIC
- CONSIDERATIONS





GE PROFILE

Established in 1892

- High-Tech Industrial Company
- Operates Worldwide through four Industrial Segments
 - Power
 - Renewable Energy
 - Aviation
 - Healthcare
- Headquarters in Schenectady, NY and Boston, MA
- End of Year 2020 – 174K employed (worldwide)



GE FINANCIALS

- Net Profits: \$79,616 B (2020); \$95,214 B (2019); \$97,012 B (2018)
- EOY 2020 Revenues Decreased by \$15.6 Billion (16%)
- Capital: \$6,597 B (2020); \$7,728 B (2019); 8,072 B (2018)
- ROIC: -2.86% (ROIC < Cost of Capital)
- WACC: 7.1% (2020), 5.1% (2019), 6% (2018)
- Debt to Equity Ratio: 3.4:1 (2020)
- **Annual Revenue has been in decline since 2016**

GE's Market Value

July 2016 \$295 Billion
July 2018 \$113 Billion
July 2020 \$60 Billion
Decreased **\$235 Billion**



WHAT WENT WRONG?



ROBERT S. KAUFMAN
"A giant in the field of strategy." —McKinsey Quarterly

GOOD STRATEGY
BAD STRATEGY

The Difference and Why It Matters

Markets

GE Falls After Being Removed From Dow Jones Industrial Average

By [Chiara Vasarri](#)

June 19, 2018, 4:35 PM CDT

Jack Welch



Larry Culp



Jeff Immelt



GE STORY

"GE brought electricity to Americans, appliances to kitchens...it's left its imprint...but GE is going to be the last of the 100-year breed..."

— Aswath Damodaron, NYU Finance Professor

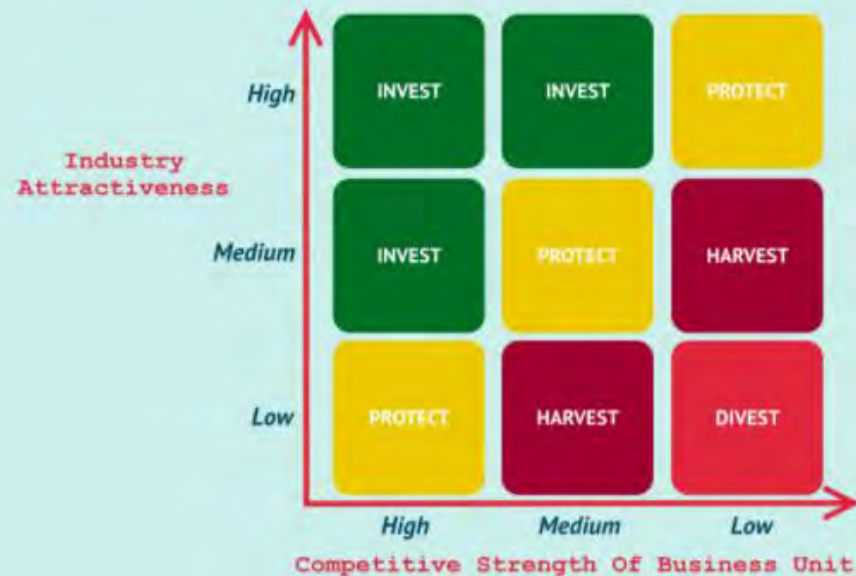


2021 OVERALL FIRM STRATEGY



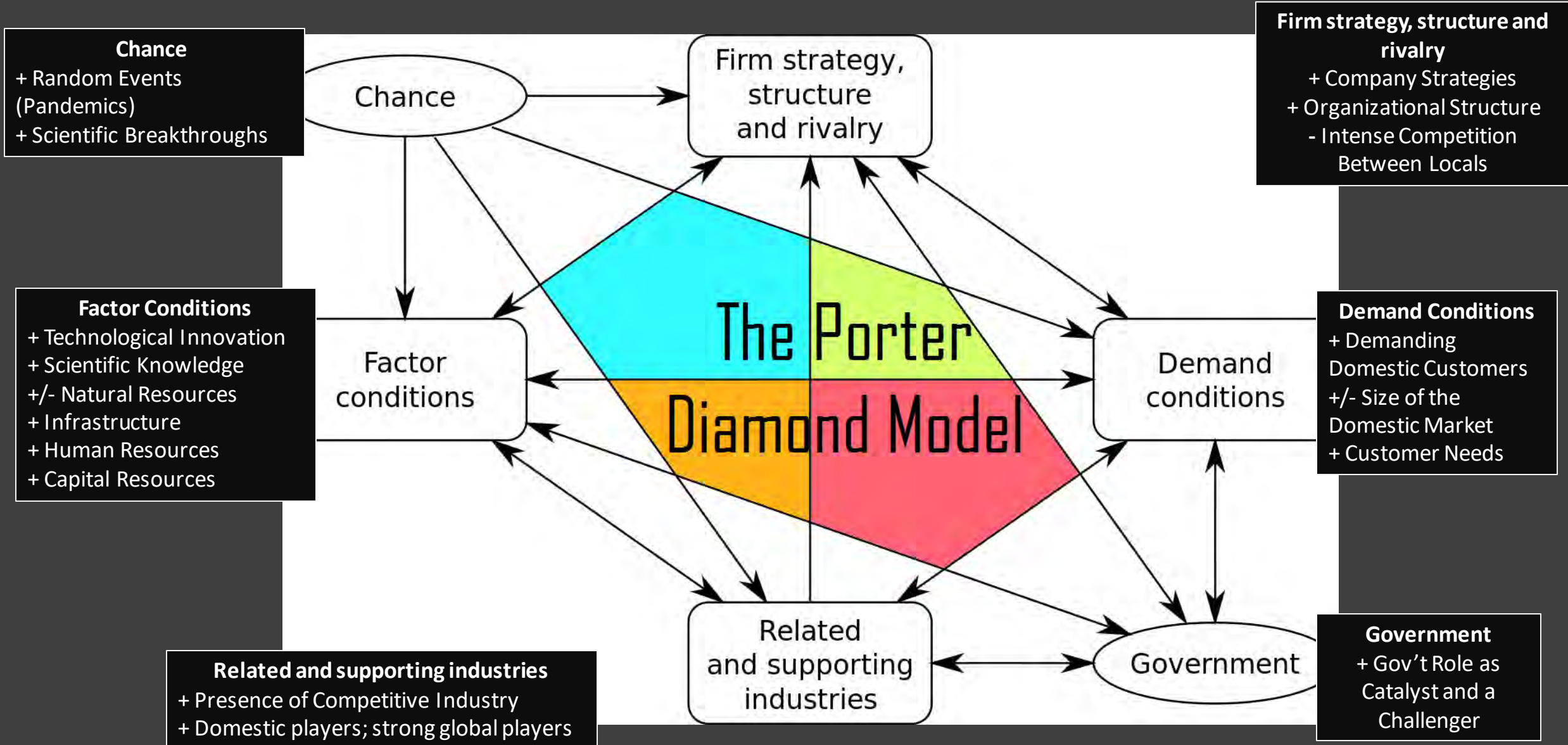
The GE McKinsey Matrix In A Nutshell

The GE McKinsey Matrix was developed in the 1970s after General Electric asked its consultant McKinsey to develop a portfolio management model. This matrix is a strategy tool that provides guidance on how a corporation should prioritize its investments among its business units, leading to three possible scenarios: invest, protect, harvest, and divest.



- Investment Driven
- Aggressive Debt Reduction Goals in 2021-2023
- Operational Actions
 - Four Segments, down from eight in 2018
 - Aims for low-single-digit sales growth
- Gains in three out of four segment—Aviation growth is the largest
- Environmental Needs

PORTER'S DIAMOND ANALYSIS



GE'S AVIATION SEGMENT

Summary of Reportable Segments (In millions)

	2019	2018	2017
Power	18,625	22,150	29,426
Renewable Energy	15,337	14,288	14,321
Aviation	32,875	30,566	27,013
Healthcare	19,942	19,784	19,017
Total industrial segment revenues	86,778	86,789	89,776



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AIRLINES.NET

GE'S STRATEGY FOR THE AVIATION SEGMENT

MONOPOLISTIC COMPETITION?

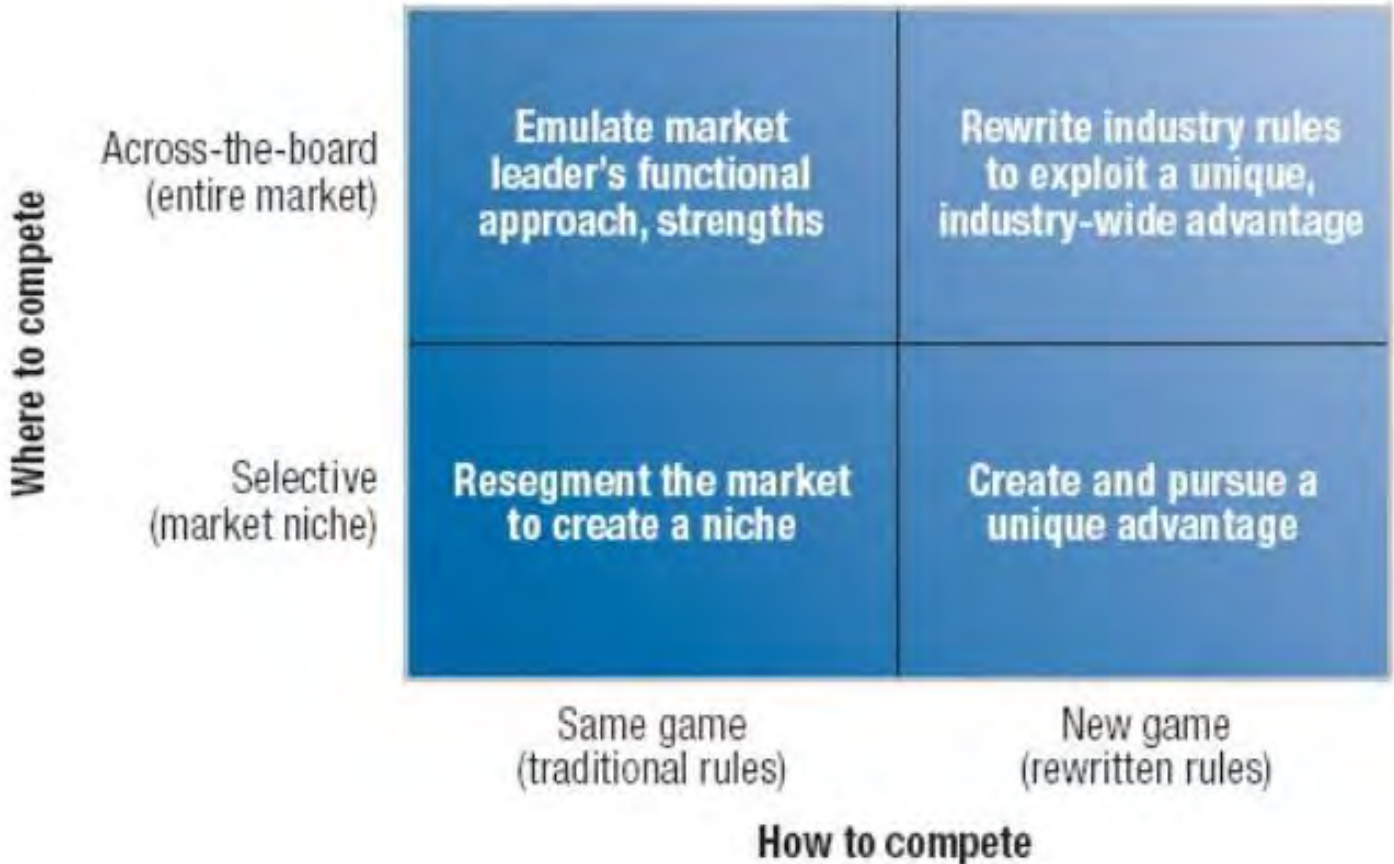
Market Structures:

Comparing Market Types

Type of Market	Number of Producers	Kind of Competition	Barriers to Entry	Another Name for Firms	Special Traits
Monopoly	One	None	No entry possible	Price-setter	Only one firm
Oligopoly	A few	Primarily non-price competition	Medium barriers (difficult entry)	N/A	Firms can collude and behave as a monopolist
Monopolistic Competition	Many	Non-price competition; price competition	Low barriers (easy entry)	Price-maker	Product differentiation and branding
Perfect Competition	A great many	Price competition	No barriers (free entry)	Price-taker	Perfectly elastic demand



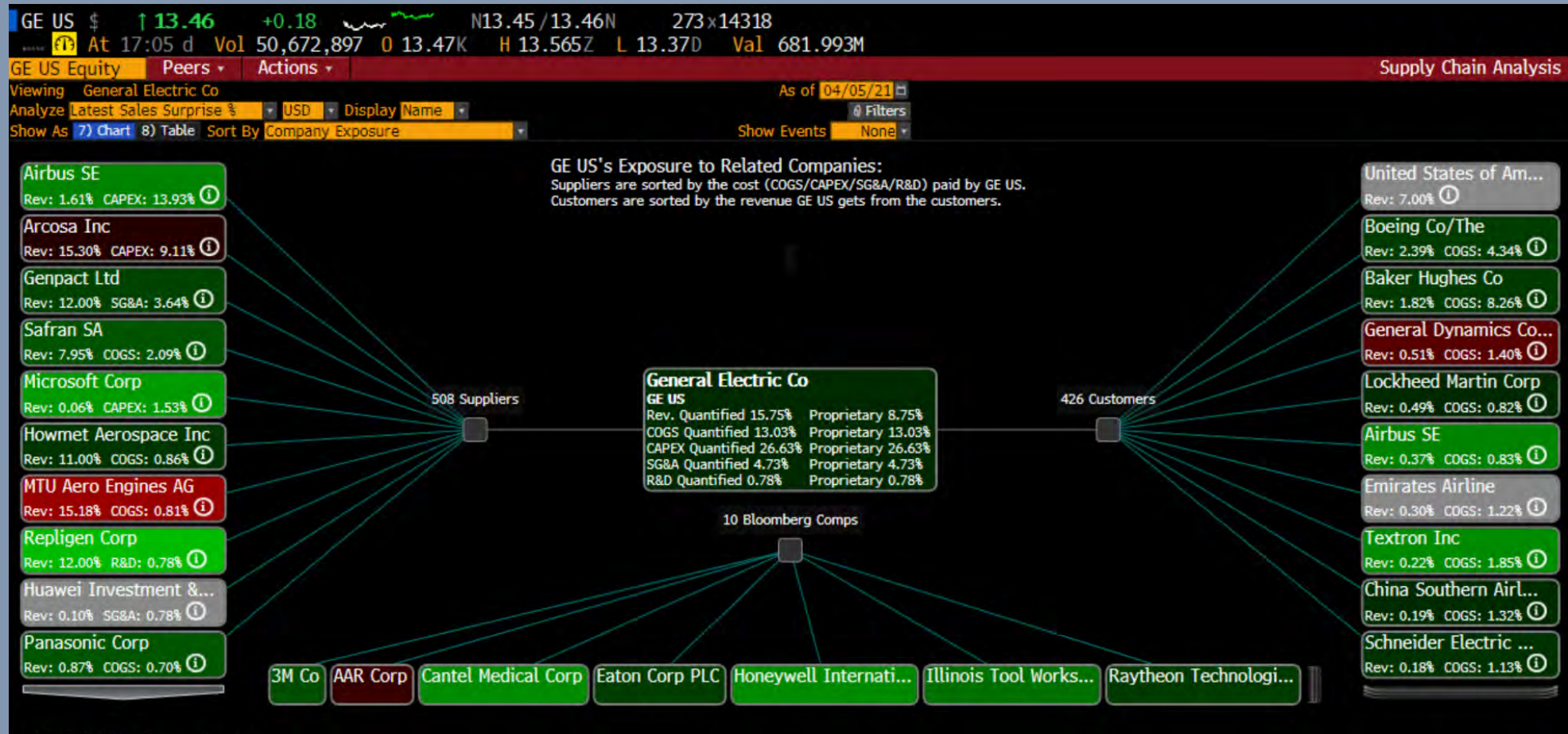
GE Aviation Competitive Advantage Position



GE Aviation Compared to its Peers

									EUROS		
GE Aviation	2017	2018	2019	Pratt & Whitney	2017	2018	2019	SAFRAN FP	2017	2018	2019
Revenue	27,013	30,566	32,875		16,160	19,397	20,892		16,900	21,000	25,000
% growth		13.2%	7.6%			20.0%	7.7%			24.3%	19.0%
Segment EBIT	5,370	6,466	6,820		1,300	1,269	1,668		2,700	2,200	3,800
% margin	19.9%	21.2%	20.7%		8.0%	6.5%	8.0%		16.0%	10.5%	15.2%
Segment D&A	979	1,042	1,150		672	852	614		1,100	1,200	1,600
% of sales	3.6%	3.4%	3.5%		2.5%	4.4%	2.9%		4.1%	5.7%	6.4%
Segment EBITDA	6,349	7,508	7,970		5,631	6,322	8,883		3800	3400	5400
% margin	23.5%	24.6%	24.2%		34.8%	32.6%	42.5%		22.5%	16.2%	21.6%
Segment Capex	1,426	1,070	1,031		(923)	(866)	(822)		-740	-780	-695
% of sales	5.3%	3.5%	3.1%		-5.7%	-4.5%	-3.9%		-4.4%	-3.7%	-2.8%
Segment FCF	4,923	6,438	6,939		6,554	7,188	9,705		4540	4180	6095
% margin	18.2%	21.1%	21.1%		40.6%	37.1%	46.5%		26.9%	19.9%	24.4%
Assets	37,473	38,021	41,647		26,768	29,341	31,170		32,200	40,600	42,800
EBIT ROA %	14.3%	17.0%	16.4%		4.9%	4.3%	5.4%		8.4%	5.4%	8.9%
ROIC %			6%				6%				7%

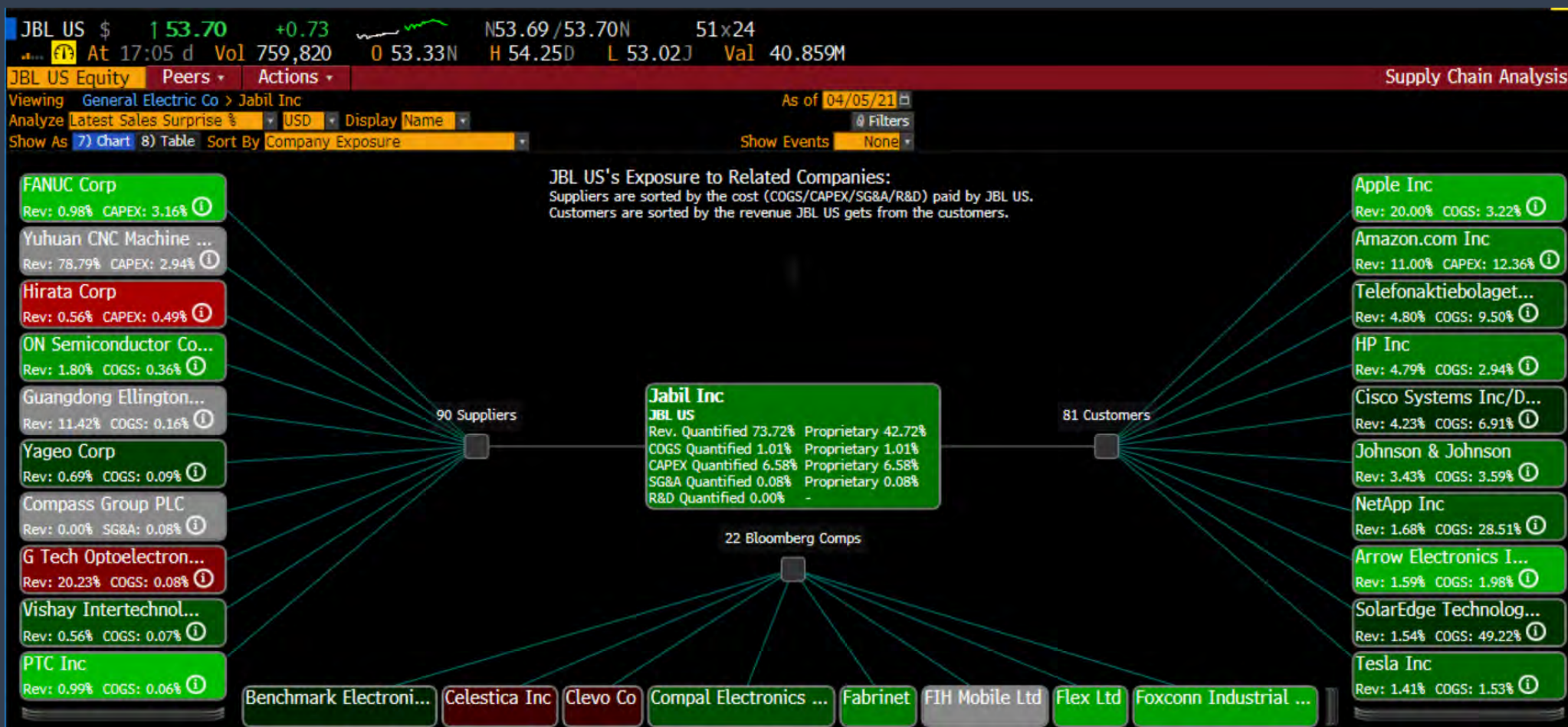
GE's Supply Chain: By Company Exposure



GE's Supply Chain: By Government Contract



Supply Chain for First Tier Prime: Jabil Inc.



Jabil Inc. Supply Chain: by Country of Domicile

At 17:05 d Vol 50,703,587 0 13.47K H 13.5652 L 13.3

JBL US Equity Peers Actions

Viewing General Electric Co > Jabil, Inc

Analyze Latest Sales Surprise % USD Display Name

Show As 7) Chart 8) Table View Suppliers

Add Column 12 Fields

Group By Country of Domicile H0 Stats...

Name	Country	Market Cap	Sales Surprise	%Revenue
21	Canada (3 securities)			
22	China (22 securities)			
23	France (1 security)			
24	Germany (1 security)			
25	India (1 security)			
26	Japan (4 securities)			
27	Singapore (1 security)			
28	South Korea (1 security)			
29	Sweden (2 securities)			
30	Switzerland (1 security)			
31	Taiwan (17 securities)			
32	United Kingdom (3 securities)			
33	United States (33 securities)			
34	Vietnam (1 security)			

IMPACT OF COVID 19 AND FUTURE

2020 GE Aviation:

- Engine Sales down 48%
- Service down 36%
- Reporting profit down 82%

C19 as an Accelerant

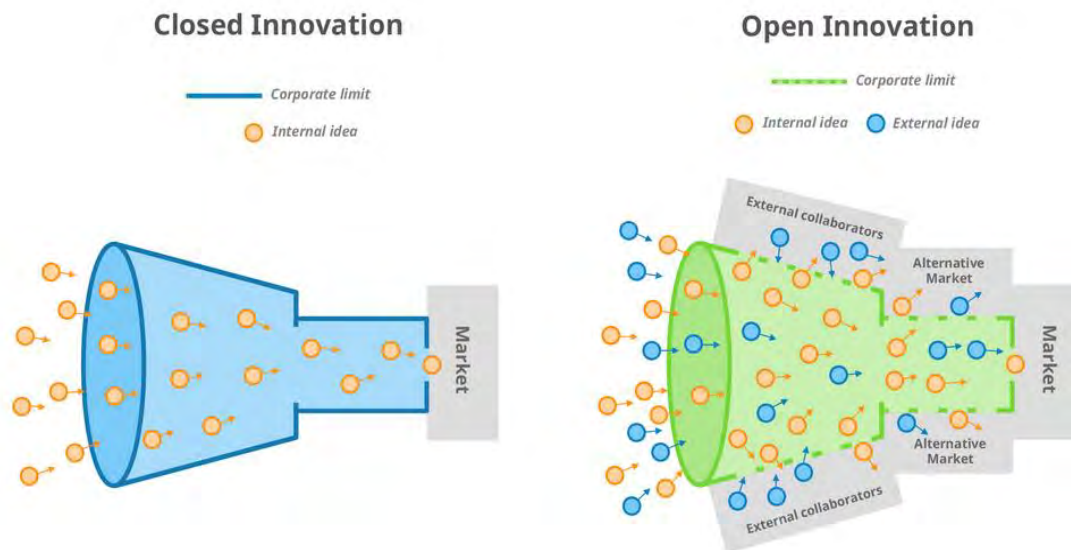
- Supply Chain Resiliency
- Additive Manufacturing





GE Innovation Challenge: Alternative Manufacturing of Aviation Castings

INNOVATION



- **Open Innovation** is the use of goal-directed inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation.
- **GE leads the way** with the use of open innovation for Aviation AM (among other GE segments) through shared processes and techniques (global, academic, and individual) to accelerate product and technology development.
- GE uses open innovation to apply to **toughest high value priorities** such as alternative manufacturing of aviation castings.
- **GE's leadership in open innovation challenge** led to the adaptation of **additive manufacturing** and creation of **GE Additive**



Ethics

- Reputation for integrity and compliance is a competitive advantage
- System of policies, processes, training and communications (*The Spirit & The Letter*)
- GE leadership driven and supported by compliance processes of prevention, detection, and response
- "Open reporting environment"





HUMAN CAPITAL CHALLENGES

- AM industry growth has created significant gaps and challenges with hiring skilled labor to meet demand of a highly technical, specialized, competitive, and fast-moving industry.
- Main contributors to AM human capital challenges: Recruitment, hiring, training, and retention.
- GE is not immune to AM industry human capital challenges
- What has GE doing to address AM human capital challenges?



- Embracing new kinds of talent.
- GE now has more senior people from outside the company than at any time in its history.
- Increased its employment of women, minorities, and workers from outside the U.S.
- Participates, promotes, and engages with:
 - America Makes
 - The Digital Manufacturing and Design Innovation Institute (DMDII)
 - National Skills Coalition
 - Carnegie Mellon University and other universities and institutes
 - Oak Ridge National Labs
 - ONR, MANTECH, AFRL (DOD) for R&D
- Transforming culture and operating rhythm, choosing speed over bureaucracy.
 - "Time is currency and our primary performance measure is speed" (GE)



FUTURE OF GENERAL ELECTRIC

- Developing the world's largest jet engine for Boeing 777X (\$4.3 billion investment)
- Electric Engine. Designing and developing hybrid electric aviation systems technology (17 projects awarded to GE through Advanced Research Projects Agency-Energy (ARPA-E))
- Jet engines for hypersonic air travel

A photograph of a GE industrial facility, likely a power plant or manufacturing plant. The image shows a complex network of pipes, metal structures, and machinery. A sign in the center reads "SCHEDULED MAINTENANCE" with a list of items and dates. The GE logo is visible on a structure in the background. The overall scene is industrial and technical.

FUTURE OF GENERAL ELECTRIC

- Continued prioritized development for military jet engines for all DOD services.
 - "GE continues to execute on bold technical initiatives to ensure even more demonstrable support to the warfighter and those in need of humanitarian relief" (GE)
 - Reengining the B-52
 - Engineering ramp up for military applications through transition of 1K engineers from commercial programs to military programs

U.S. ADDITIVE MANUFACTURING & GREAT POWER COMPETITION

- Benefits
 - Strengthens U.S. Economy
 - Supply Chain Independence
- Challenges
 - Made in China 2025
 - Human Capital / STEM skills

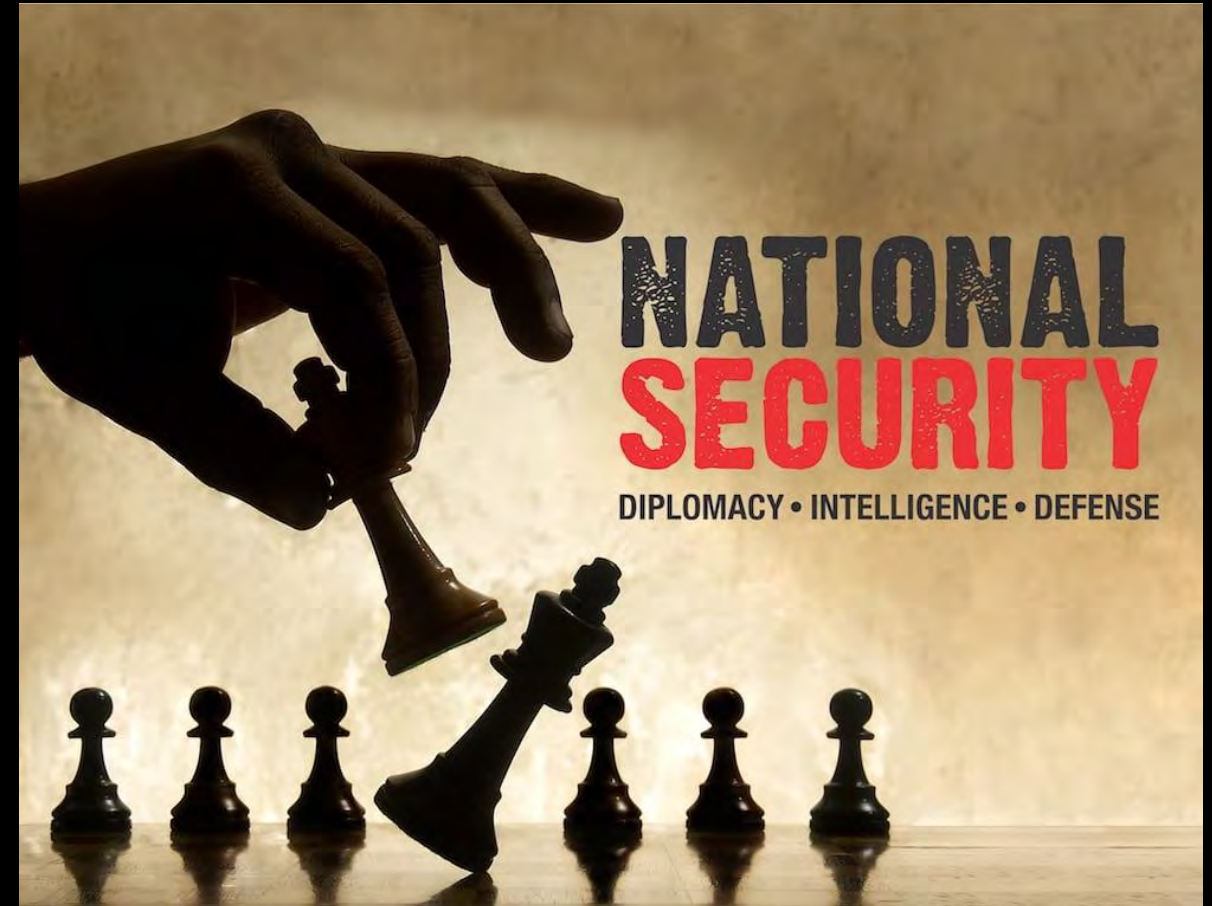


PRODUCTS RELEVANT TO NATIONAL SECURITY

- 3D Printers
- From Design to Product – *the Process*
- Jet Engines
- Aircraft Components
- Medical Devices
- Bridges, Buildings, etc...

POLICY CONSIDERATIONS

- Surge & Mobilization—Integrate AM in Joint Forces
- Strive to Eliminate All IP Theft
- Disrupt global supply chain
- Error-proof!





GENERAL ELECTRIC

QUESTIONS?

IBM Firm Brief

Saif Al Mesafri

Agustinus Tambunan

Illya Thomas

Max Jonson

Seminar 14

IBM Firm Brief

- IBM Profile
- Story
 - Servers
 - Cloud
 - AI
- National Level Analysis – Porters Diamond
- Supply Chain
- Human Capital
- Strategy
- National Security Implications

IBM's Profile

- IBM “Big Blue” - Armonk, New York, 1911
 - Began as the Computing Tabulating Recording Co. (C-T-R)
- Employees
 - In 1914 - 1,346
 - In 2020 - 345,900 (Largest IT company in the world)
- Business Units (5)
 - Cloud & Cognitive Software
 - Global Business Services
 - Global Technology Services
 - Systems
 - Global Financing
- 1969 - IBM Computers & personnel helped NASA with moon landing
- 1997 - Deep Blue defeated Gary Kasparov in chess
- 2008 - IBM first company to earn over 4,000 U.S. patents in one year
- 2013 - Watson easily defeated two humans in jeopardy



IBM's Story

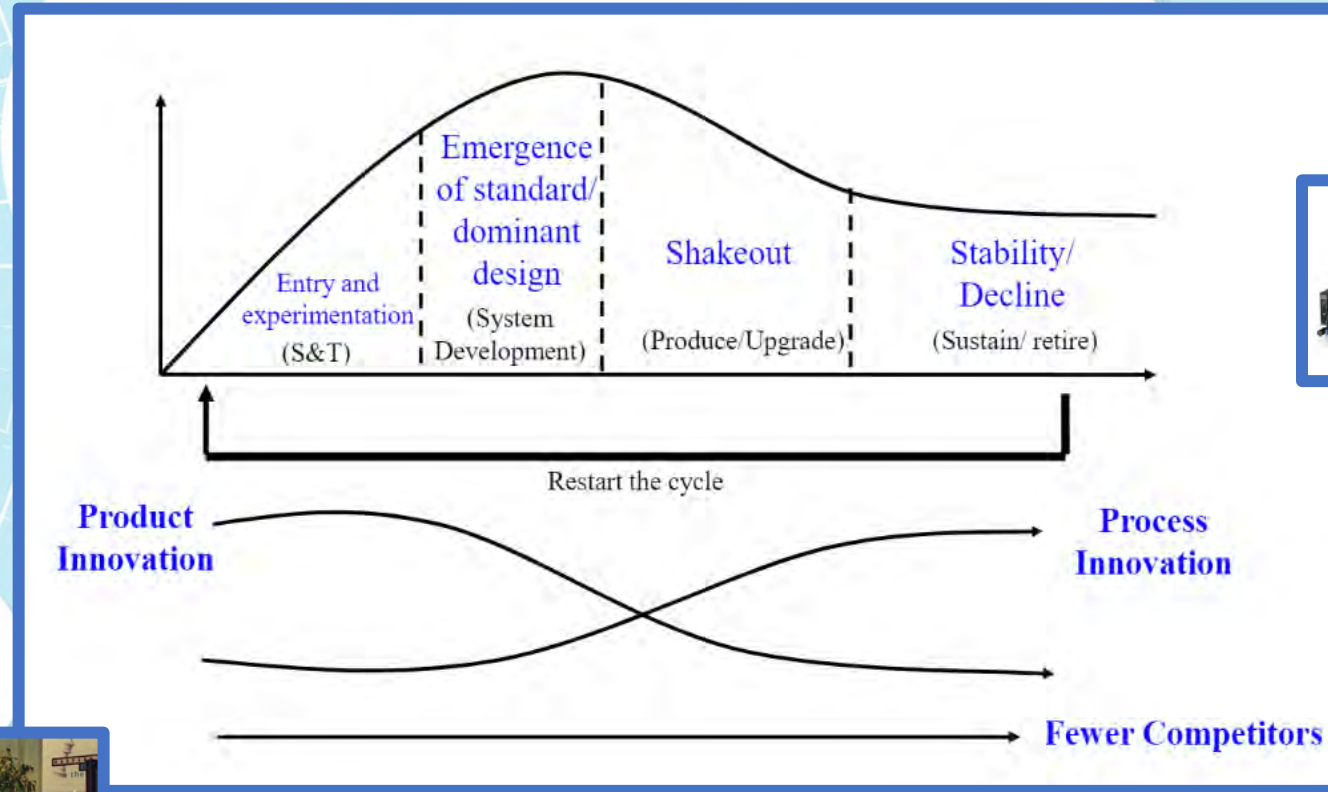
1981



1988



1997



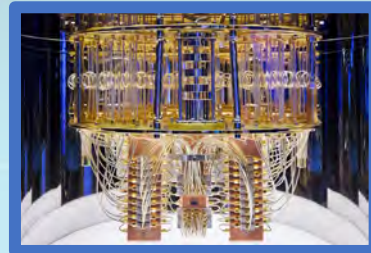
2005



2011



2023



Servers – Market Structure & Competition

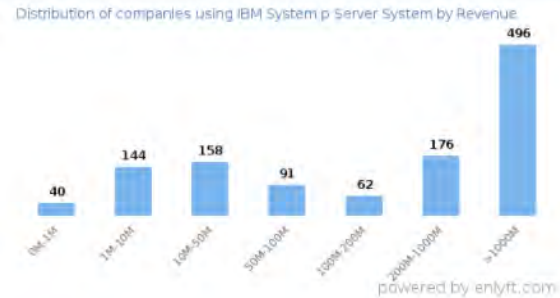
Force	Strength	Notes	Trend	Notes
Rivalry among existing competitors	Strong	Small number of firms, increasingly uniform product, geographically segmented markets	Stable	Servers increasingly seen as commodity product, quality is still a threshold but competition is largely price based
Threat of new entrants	Low	Barriers to entry include high capital requirements and incumbent advantages (reputation & proprietary knowledge)	Increase	<ul style="list-style-type: none"> - Component producers can forward integrate but typically do not due to risk - Increasing popularity of ODMs
Threat of substitute products	Moderate	<ul style="list-style-type: none"> - High brand loyalty - Data centers and web hosts are historic substitute for on-site servers 	Significant increase	Cloud-based services assume increasing percentage of market share
Bargaining power of buyers	Moderate	- Concentration of buyers who make high volume purchases	Increase	<ul style="list-style-type: none"> - Buyers are increasingly educated on technical details - Switching costs decreasing - Cloud alternative increases price sensitivity
Bargaining power of suppliers	Strong	<ul style="list-style-type: none"> - Limited number of suppliers - Requirement for specific, high purity elements - Increasingly narrow labor pool 	Stable	Relationship currently favors suppliers and will continue to do so as other markets demand their products/services

- **\$83.66B Market**
- **7.8% CGAR to 2028**
- **IBM Systems ROIC 9.78%**
 - **HP compute 6.012%**
- **9.5% of IBM's revenue**
- **Oligopoly with decreasing ability to control profits**

Servers – Customers

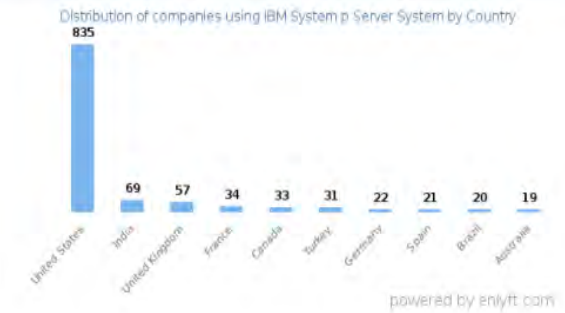
Distribution of companies that use IBM System p Server System based on company size (Revenue)

Of all the customers that are using IBM System p Server System, a majority (53%) are large (>\$1000M), 27% are small (<\$50M) and 16% are medium-sized.



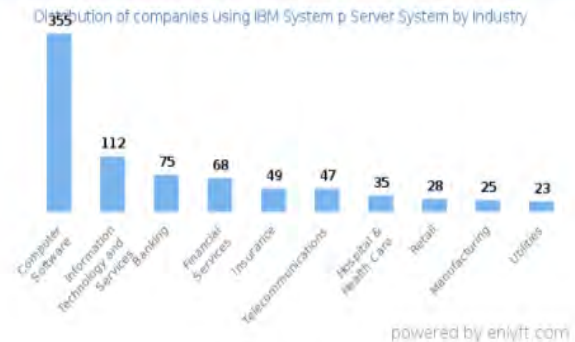
Top Countries that use IBM System p Server System

60% of IBM System p Server System customers are in United States.



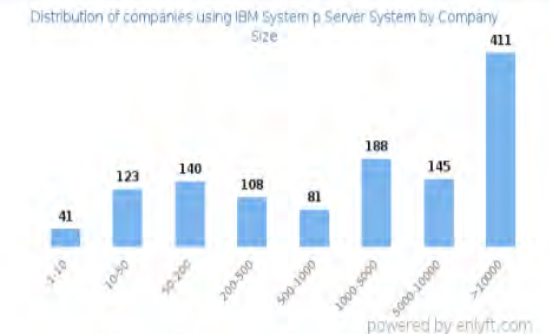
Top Industries that use IBM System p Server System

Looking at IBM System p Server System customers by industry, we find that Computer Software (26%), Information Technology and Services (8%) and Banking (5%) are the largest segments.



Distribution of companies that use IBM System p Server System based on company size (Employees)

Of all the customers that are using IBM System p Server System, a majority (58%) are large (>1000 employees), 14% are small (<50 employees) and 27% are medium-sized.



Servers – Peer Competitors

Top 5 Companies, Worldwide Server Vendor Revenue, Market Share, and Growth, Second Quarter of 2020 (Revenues are in US\$ Millions)

Company	2Q20 Revenue	2Q20 Market Share	2Q19 Revenue	2Q19 Market Share	2Q20/2Q19 Revenue Growth
T1. HPE/New H3C Group**	\$3,582.4	14.9%	\$3,646.4	18.2%	-1.8%
T1. Dell Technologies	\$3,339.8	13.9%	\$3,793.3	18.9%	-12.0%
3. Inspur/Inspur Power Systems ^b	\$2,532.9	10.5%	\$1,431.0	7.1%	77.0%
T4. Lenovo*	\$1,466.6	6.1%	\$1,212.3	6.0%	21.0%
T4. IBM*	\$1,449.7	6.0%	\$1,188.6	5.9%	22.0%
ODM Direct	\$6,917.6	28.8%	\$4,232.7	21.1%	63.4%
Rest of Market	\$4,748.1	19.8%	\$4,563.5	22.7%	4.0%
Total	\$24,037.1	100.0%	\$20,067.8	100%	19.8%

Top 5 Companies, Worldwide Server Unit Shipments, Market Share, and Growth, Second Quarter of 2020

Company	2Q20 Unit Shipments	2Q20 Market Share	2Q19 Unit Shipments	2Q19 Market Share	2Q20/2Q19 Unit Growth
T1. HPE/New H3C Group**	456,642	14.3%	443,632	16.5%	2.9%
T1. Dell Technologies*	432,556	13.6%	479,941	17.8%	-9.9%
3. Inspur/Inspur Power Systems ^b	353,329	11.1%	231,404	8.6%	52.7%
4. Lenovo	193,086	6.1%	181,165	6.7%	6.6%
T5. Supermicro*	152,411	4.8%	139,289	5.2%	9.4%
T5. Huawei*	138,849	4.4%	116,994	4.3%	18.7%
ODM Direct	1,096,765	34.4%	678,940	25.2%	61.5%
Rest of Market	364,257	11.4%	420,092	15.6%	-13.3%
Total	3,187,894	100.0%	2,691,457	100.0%	18.4%

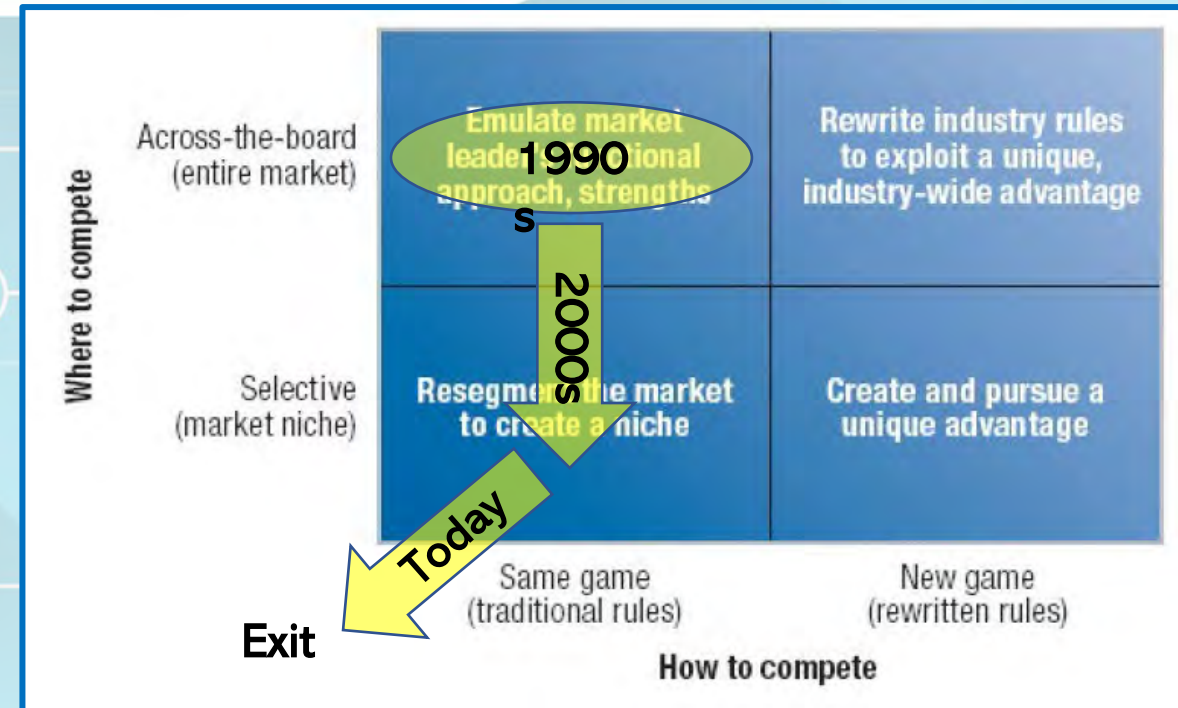
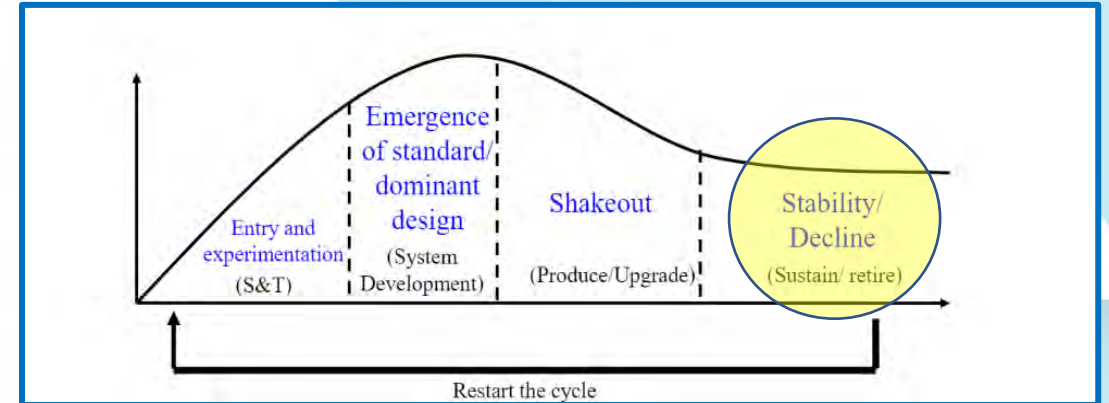
Source: IDC Worldwide Quarterly Server Tracker, September 8, 2020

#10

- IBM is charging existing customers a premium price for a product which customers increasingly view as a commodity

Servers – Strategy & Activities

- Support existing customer's transition to hybrid cloud while exiting server market
- Actives aligned with strategy
- Strategic Divestment
 - IBM GTS / "NewCo" Split
 - Sold x86 server business to Lenovo in 2014
- Increased OEM partnerships for procurement
- Direct sales to existing customers



Cloud – Competitive Spectrum

MARKET STRUCTURE

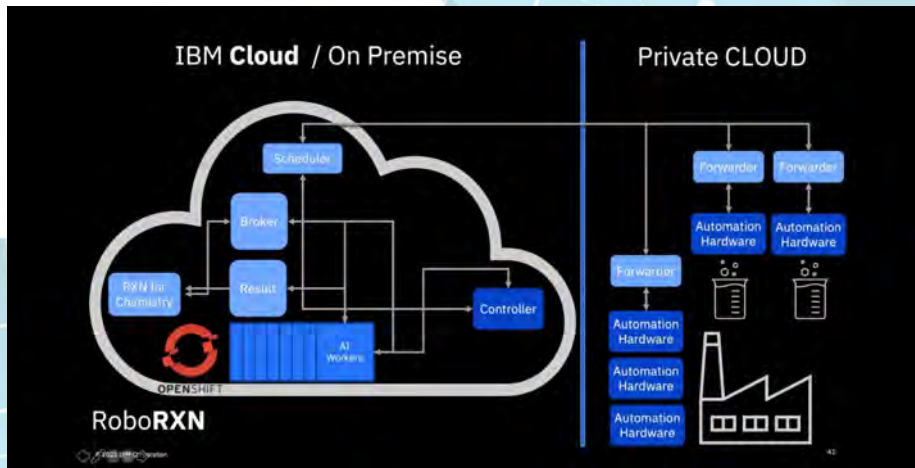
<i>CHARACTERISTIC</i>	<i>PERFECT COMPETITION</i>	<i>MONOPOLISTIC COMPETITION</i>	<i>OLIGOPOLY</i>	<i>MONOPOLY</i>
<i>Number of firms</i>	<i>Many</i>	<i>Many</i>	<i>Few</i>	<i>One</i>
<i>Type of product</i>	<i>Identical</i>	<i>Differentiated</i>	<i>Identical or differentiated</i>	<i>Unique</i>
<i>Ease of entry</i>	<i>High</i>	<i>High</i>	<i>Low</i>	<i>Entry blocked</i>
<i>Examples of industries</i>	<ul style="list-style-type: none">• <i>Wheat</i>• <i>Apples</i>	<ul style="list-style-type: none">• <i>Selling DVDs</i>• <i>Restaurants</i>	<ul style="list-style-type: none">• <i>Manufacturing computers</i>• <i>Manufacturing automobiles</i>	<ul style="list-style-type: none">• <i>First-class mail delivery</i>• <i>Tap water</i>

Cloud – Industry Structure

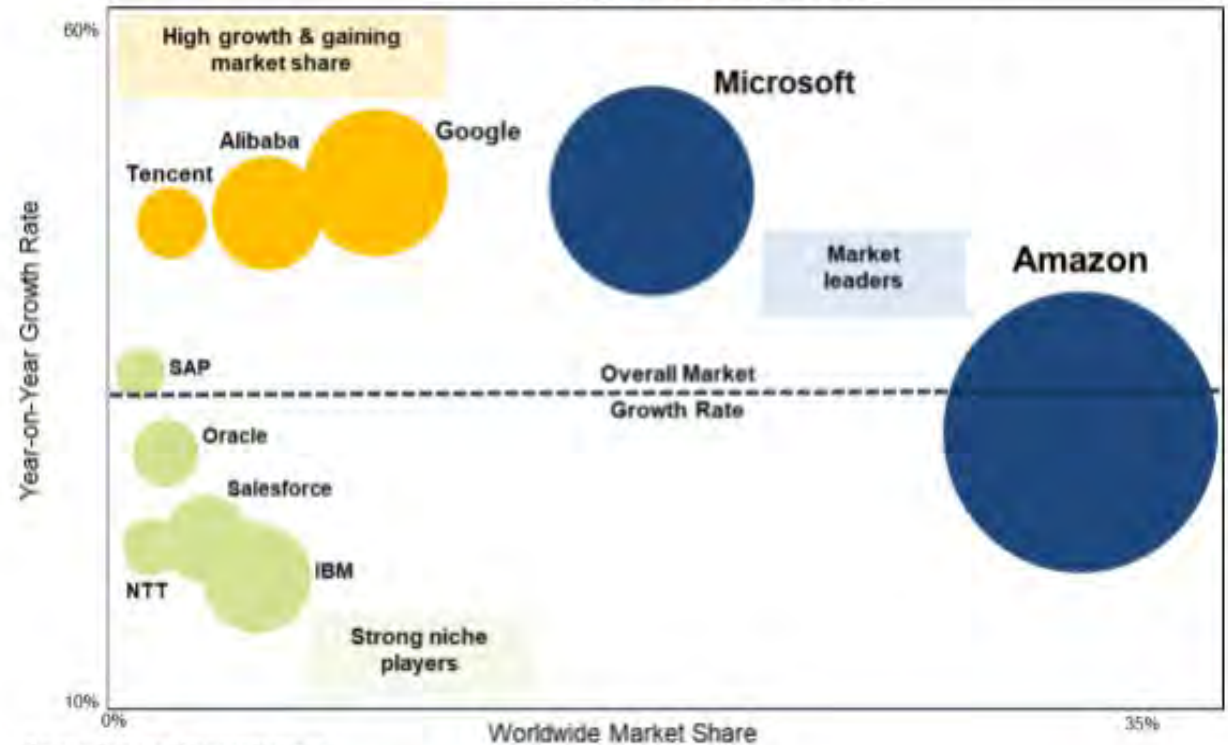
Force	Strength	Notes	Trend	Notes
Rivalry among existing competitors	Strong	<ul style="list-style-type: none"> - Competition dominated by large companies--the Big 5 - Acquisitions and mergers with smaller firms for innovative solutions 	Stable	<ul style="list-style-type: none"> - Industry is fragmented with small players competing against larger players who are increasingly focused on acquisition
Threat of New Entrants	Moderate	<ul style="list-style-type: none"> - Hi-tech, highly specialized industry - Large companies offer desired scale - Small companies struggle w/ restrictions (reputation & proprietary knowledge) 	Increase	<ul style="list-style-type: none"> - Component producers can forward integrate but typically do not due to risk - Increasing popularity of ODMs
Threat of Substitute products	Weak	<ul style="list-style-type: none"> - High brand loyalty - Data centers and web hosts are historic substitute for on-site servers 	Significant Increase	<ul style="list-style-type: none"> - Cloud-based services assume increasing percentage of market share
Bargaining power of buyers	Moderate	<ul style="list-style-type: none"> - Varying buyers from small business to multinational corporations and government agencies - Contracts offered in a pay-as-you-go format, charging according to usage 	Increase	<ul style="list-style-type: none"> - Buyers are increasingly educated on technical details - Switching costs decreasing - Cloud-based alternative increases price sensitivity
Bargaining power of suppliers	Strong	<ul style="list-style-type: none"> - Limited number of suppliers - Requirement for very specific rare earth elements of highest purity - Increasingly narrow labor pool 	Stable	<ul style="list-style-type: none"> - Relationship currently favors suppliers and will continue to do so as other markets demand their products/services

Cloud – Peer Competitors

- \$371.4B Market
- 17.5% CGAR to 2025
- Cloud & Cognitive Software
 - 31.75% of IBM's revenue



Cloud Provider Competitive Positioning
(IaaS, PaaS, Hosted Private Cloud - Q3 2020)



Source: Synergy Research Group
Source: Synergy Research Group

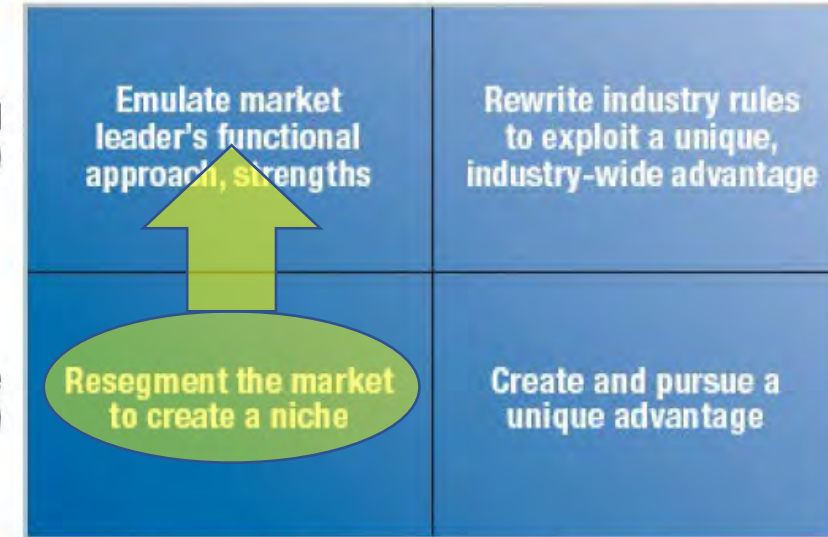
Cloud – Strategic Game Board

- **Strategic acquisition of companies and new client portfolios**
 - Red Hat acquired in 2019
 - OpenShift hybrid cloud data platform
 - Serves 47 of the Fortune 50 companies
- **Growth - BIG Data**
 - IoT
 - Edge Computing
 - 5G
 - Artificial Intelligence
 - Machine Learning

Where to compete

Across-the-board (entire market)

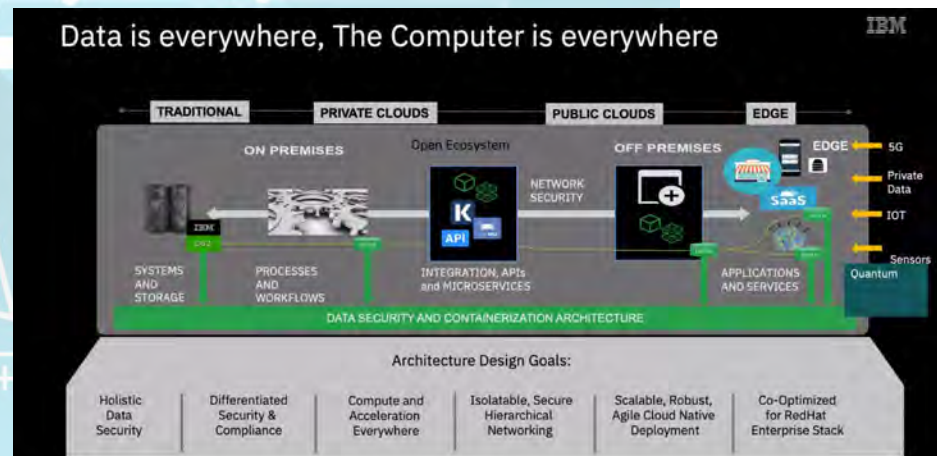
Selective (market niche)



Same game (traditional rules)

New game (rewritten rules)

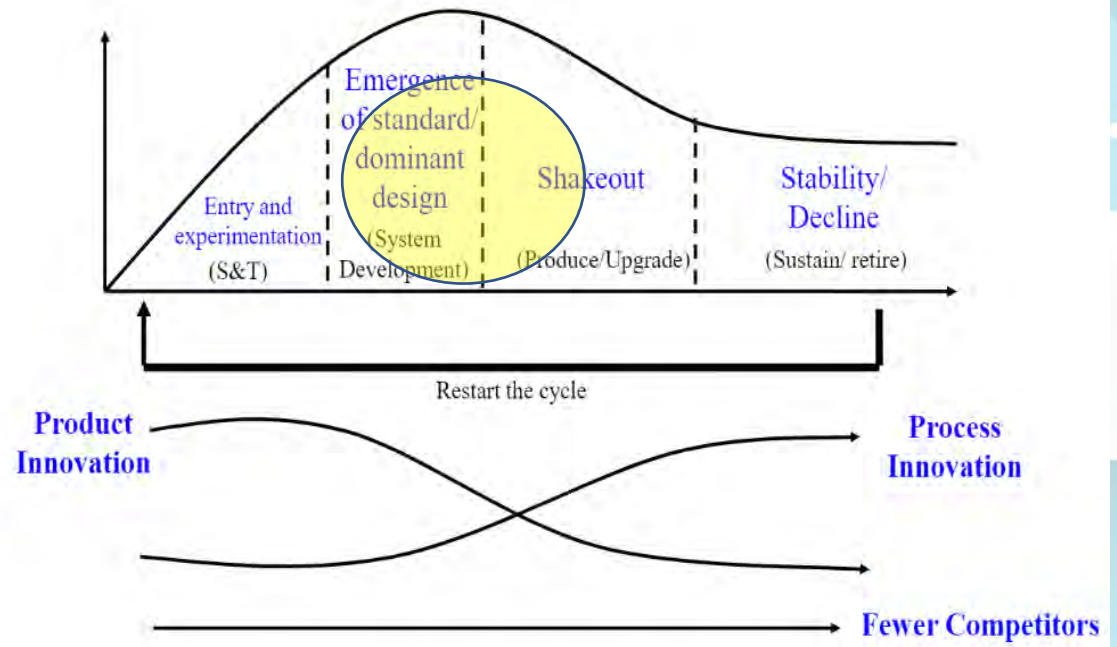
How to compete



Cloud – Industry Lifecycle

- **OpenShift Platform for Workflow Development and Deployment**
 - Public, Private, or On-premise Cloud
 - Platform as a Service (PaaS)
 - Software as a Service (SaaS)
- **Growth - IBM projects \$1T hybrid cloud opportunity**
 - Less than 25% of workloads on public clouds
 - AI only in single digits

View #2: The Lifecycle of the Technology/Industry Sector...

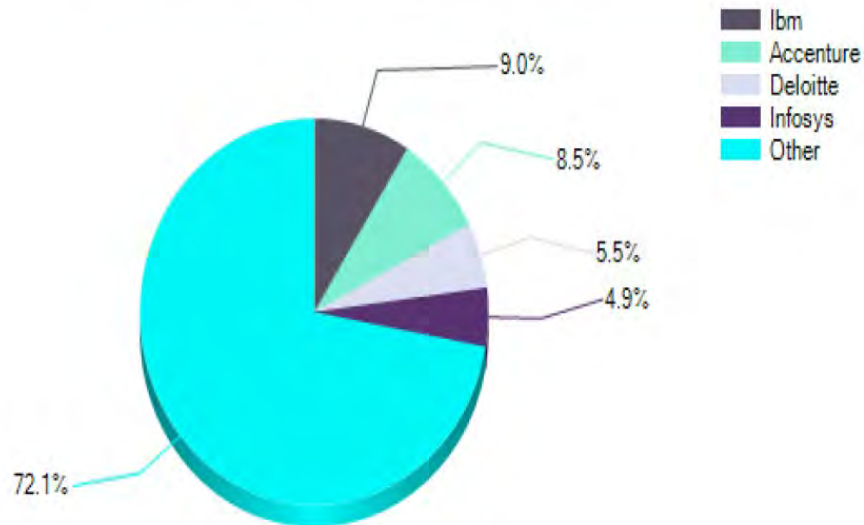


AI Market

- Who is leading
- AI leading strategies
- Notable contracts/partnerships

- IBM invests 6.8% of revenues in R&D, strategy scaling A.I. solutions
- Accenture R&D partnership Google/Amazon rev \$43.2B, strategy human interaction, human element and geographical expansion.

Global artificial intelligence market share: % share, by value, 2019



A. The race for leadership

Global distribution of AI startups

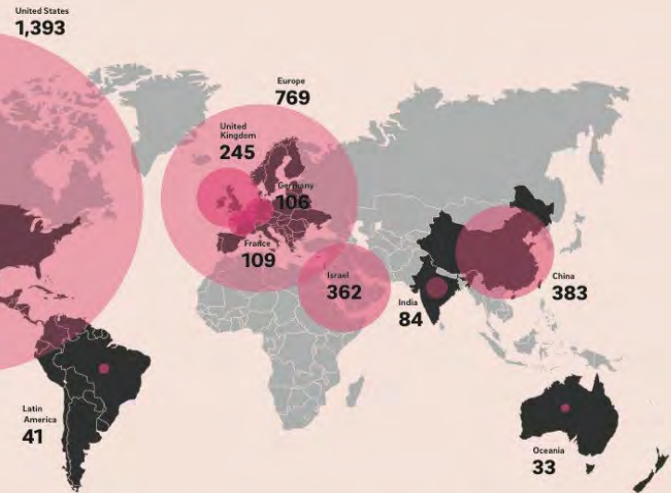
Top countries and cities by number of startups

Rank	Country	Number of Startups
1	United States	1,393
2	China	383
3	Israel	362
4	United Kingdom	245
5	Canada	113
6	Japan	109
7	France	109
8	Germany	106
9	India	82
10	Sweden	65
11	Finland	45
12	South Korea	42
13	Spain	39
14	Singapore	35
15	Switzerland	28
16	Australia	27
17	Brazil	26
18	Netherlands	24
19	Italy	22
20	Russia	19

Top regional hubs

Cities' extended urban areas^{1,2}

Rank	City	Number of Startups
1	San Francisco	506
2	London	211
3	Tel Aviv	189
4	New York	180
5	Beijing	150
6	Boston	102
7	Tokyo	99
8	Shanghai	77
9	Los Angeles	73
10	Paris	73
11	Shenzhen	66
12	Berlin	56
13	Toronto	47
14	Seoul	42
15	Austin	36
16	Washington	36
17	Seattle	35
18	Singapore	35
19	Bangalore	32
20	Helsinki	32



¹ Regional hubs center on a core city plus its extended urban area and wider agglomeration (e.g. San Francisco plus Bay Area, London plus Greater London & Conurbation etc.). ² Beijing and Taipei: Administrative boundaries only. ³ Beijing excluding 30 districts for which information on city was not available. Among them, 150 are located in Haidian.



AI – Competitive Spectrum

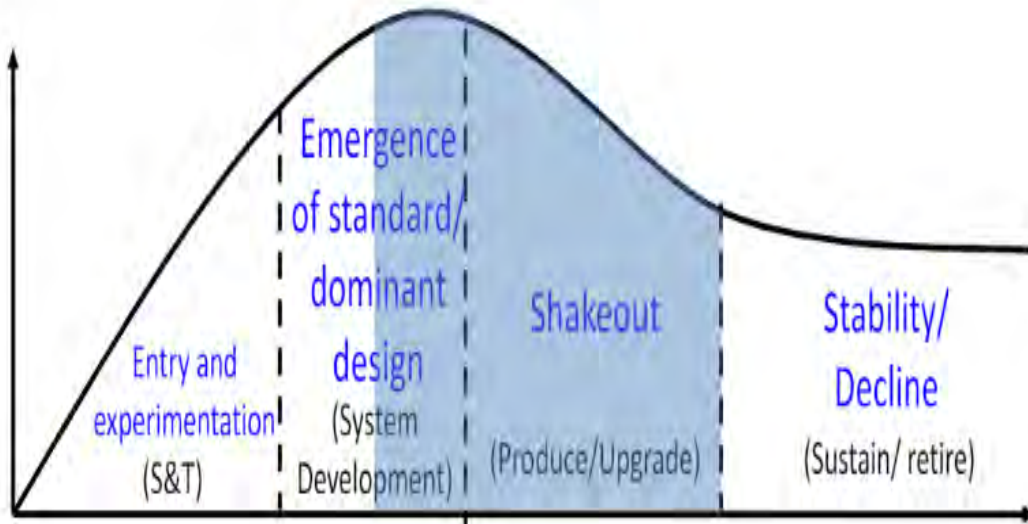
<i>MARKET STRUCTURE</i>				
<i>CHARACTERISTIC</i>	<i>PERFECT COMPETITION</i>	<i>MONOPOLISTIC COMPETITION</i>	<i>OLIGOPOLY</i>	<i>MONOPOLY</i>
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AI – Market Structure

Force	Strength	Notes	Trend	Notes
Rivalry among existing competitors	High	Typical competitor in this market is small Service differentiation in the market/low cost no rivalry Higher levels of maintenance required when companies upscale their userbases.	Increase	Able to be scaled as demand grows Very flexible Exit barriers are likely to be low because of the high levels of M&A activity, driven by equity funds .
Threat of New Entrants	Moderate	Seek more affordable options Differentiation of AI services is very high, because niche applications/ differentiate within applications	Stable	- Access to distribution channels and suppliers for new entrants in this market. - Complexity of AI solutions and the intellectual property
Threat of Substitute products	Low	- not available/operating less efficiently - alternative to AI is de-automation, which is inherently more expensive.	Stable	Implement AI, consumers have little alternative.
Bargaining power of buyers	Moderate	- Concentration of buyers who make high volume purchases - Serving larger numbers of smaller business one-size-fits-all platform - switching costs very high	Stable	- forward integration
Bargaining power of suppliers	Moderate-High	- Technically-skilled staff are a critical input for players . - Competition for talented developers is strong among large-scale players. - Raw materials /alternatives to hardware and software inputs are costly.	Significant Increase	IBM backwards integrated with their own hardware and software manufacturing capabilities, and less reliance on external suppliers (semiconductors)

AI – Technology Lifecycle

- The lifecycle of the AI
- IBM AI market strategy



Hype Cycle for Artificial Intelligence, 2020

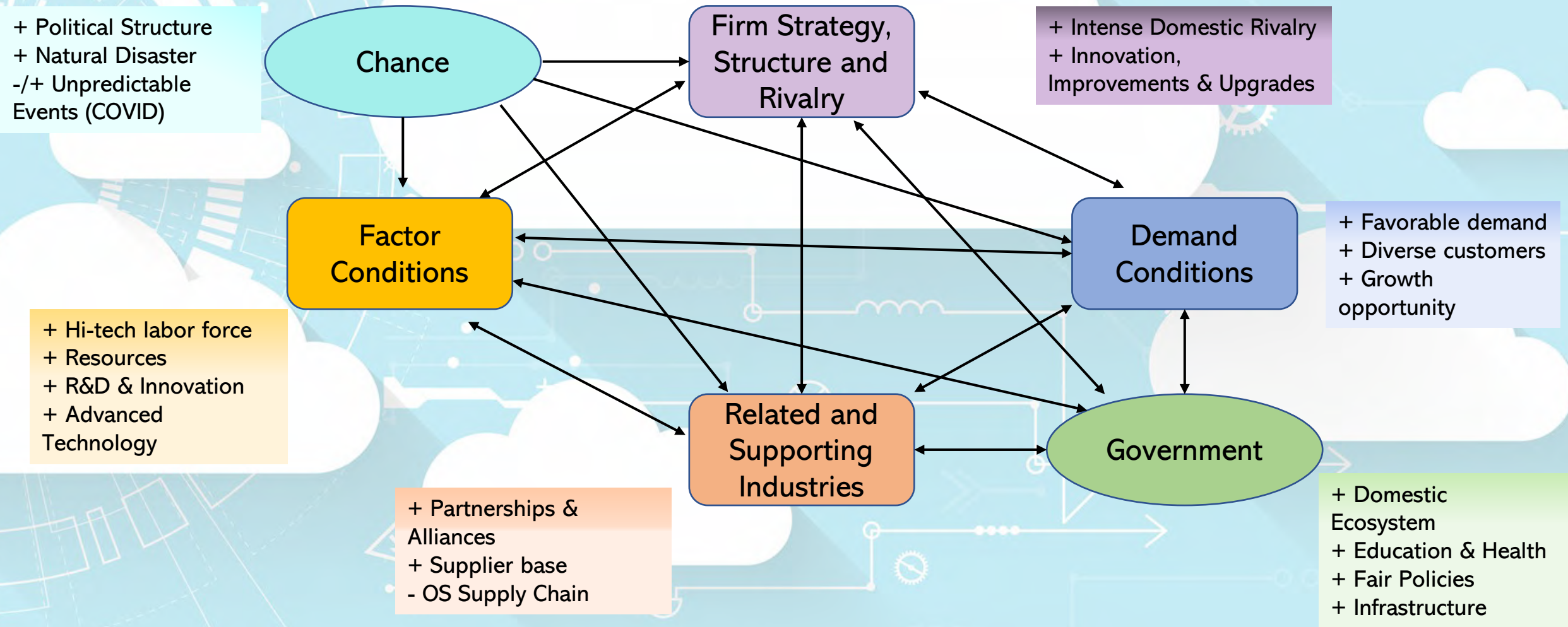


Plateau will be reached:

- less than 2 years
- 2 to 5 years
- 5 to 10 years
- ▲ more than 10 years
- ⊗ obsolete before plateau

As of July 2020

Porter's Diamond Analysis



IBM Supply Chain

- **Diverse Supply Chain**
 - 364 Suppliers and 677 Customers
- **Vulnerability**
 - Semiconductors
- **H.R. 7178 CHIPS for America Act**
 - Support U.S. semiconductor manufacturing, research and development, and supply chain security

Beyond Borders: Semiconductors are a Uniquely Global Industry

Typical semiconductor production process spans multiple countries: 4+ Countries, 4+ States, 3+ trips around the world, 25,000 miles travelled, 100 days TPT, 12 days in transit

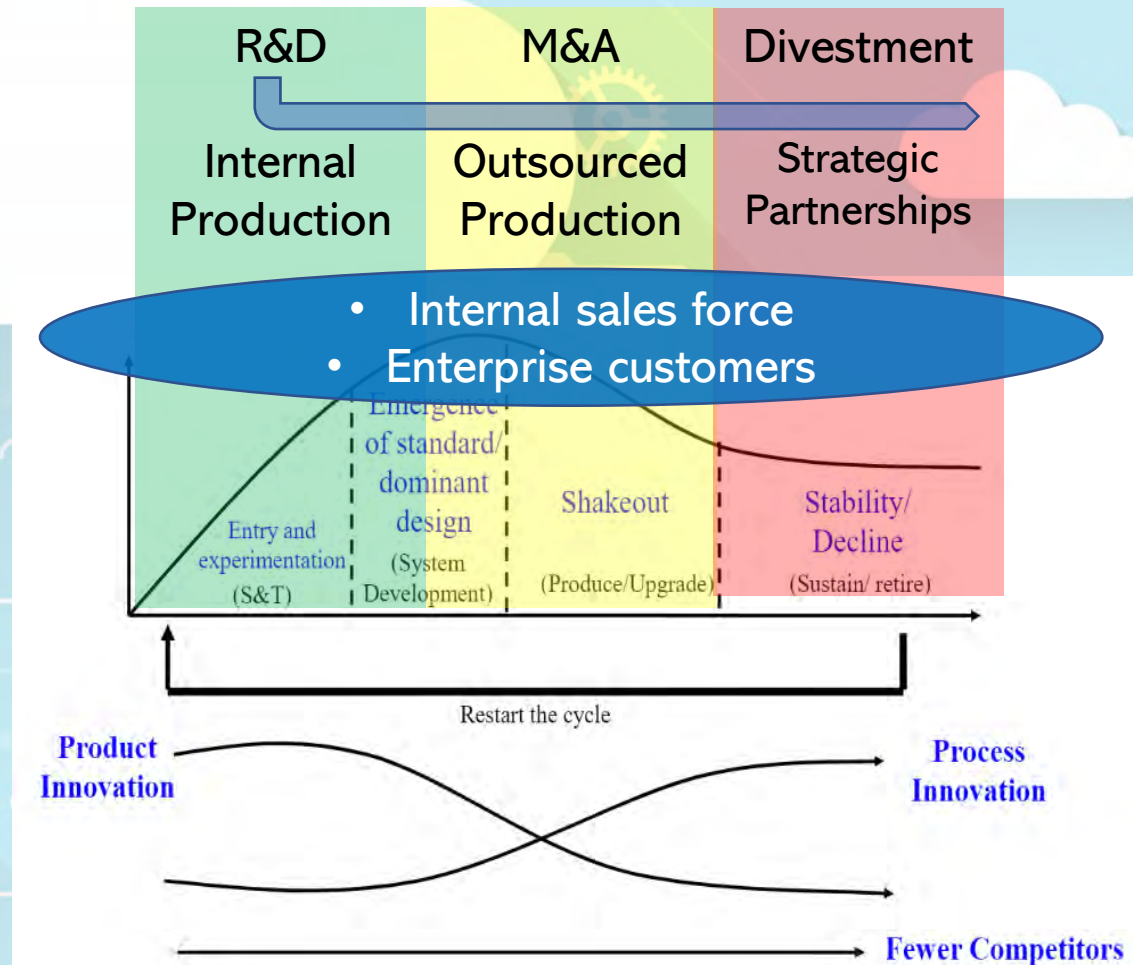


Human Capital

- By 2030 global shortage of more than 86 million tech workers. In US there are more than 500,000 open jobs in tech-related sectors. As many as 1 million programming jobs will be unfilled by 2020. US is experiencing a shortage of 4-year college degree in tech and industry.
- IBM will hire unconventional backgrounds and train them according to company needs.
- IBM would be partnering with community colleges across the U.S. to better prepare more Americans for “new collar career opportunities.”
- Internally, IBM has several programs to fill the gap the tech skills: **Blue Matching; CogniPay; Career Coach**
- IBM partnerships with community college, academia, university, scholarship, training.

IBM Firm Strategy & Activities

- **Focused differentiation:** Help enterprise customers adopt high quality, high margin, disruptive technologies
- **Objective:** Maximize profit in Cloud and AI, shift R&D to next disruptive technology, divest hardware
- **Scope**
 - **Customer Offering:** High-end, tailored products, disruptive technologies
 - **Location:** Enterprise customers, heavily domestic
 - **Vertical Integration:** Downstream
- **Advantage**
 - **Value Proposition:** Premium price for trusted name, enterprise solutions through disruptive technologies
 - **Activities:** Direct sales & marketing, R&D, M&A, strategic divestment
 - **Competitive Advantages:** Customer relationships/reputation, open architecture



IBM Firm Strategy Implications

- Why this strategy works
- *“We all need to understand and leverage IBM’s sources of competitive advantage.” “Namely, our **open source** and security leadership, our **deep expertise and trust**, and the fact that we enable clients to build mission-critical applications once and run them anywhere.” - Arvind Krishna, CEO*
- This strategy creates value
 - ROIC 43.24% > WACC 6.2% (industry average)
 - D-E Ratio 6.52, industry average 1.11
- What is the purpose of a Corporation?
 - 105 years of dividends
 - 25 years of increased dividends
- Impact on NDS identified technologies
 - Advanced computing, big data, AI, autonomy, DE, hypersonics, biotech

(\$ in millions)

For the year ended December 31:	2020	2019	Yr.-to-Yr. Percent/Margin Change	Yr.-to-Yr. Percent Change Adjusted for Currency
Revenue				
Cloud & Cognitive Software	\$23,376	\$22,891 *	2.1 %	1.9 %
Gross margin	77.5 %	77.1 %*	0.4 pts.	
Global Business Services	16,162	16,798 *	(3.8)%	(4.1)%
Gross margin	29.7 %	27.7 %*	2.0 pts.	
Global Technology Services	25,812	27,361	(5.7)%	(5.4)%
Gross margin	34.8 %	34.8 %	0.0 pts.	
Systems	6,978	7,604	(8.2)%	(8.7)%
Gross margin	55.9 %	53.1 %	2.8 pts.	
Global Financing	1,123	1,400	(19.8)%	(19.2)%
Gross margin	37.7 %	35.6 %	2.1 pts.	
Other	169	1,092 *	(84.5)%	(84.4)%
Gross margin	NM	12.5 %*	NM	

- Systems ROIC: 9.78%
- Cloud and Cognitive Software ROIC: 10.83%

National Security Policies

- “Secure” semiconductor supply chain
 - CHIPS for America
- Develop low-density high-demand skillsets
- Encourage adoption of emerging international standards
 - Counter to China Standards 2035
- Targeted R&D assistance
 - IBM’s focus is high-revenue, disruptive technologies with business applications
 - Valley of Death
 - Early & continuous cooperation
 - Leverage IBM salesforce (Global Technology Services & Global Business Services)
- Identify alternative hardware vendors NOW
 - Transition networks to zero trust architecture

IBM's Story

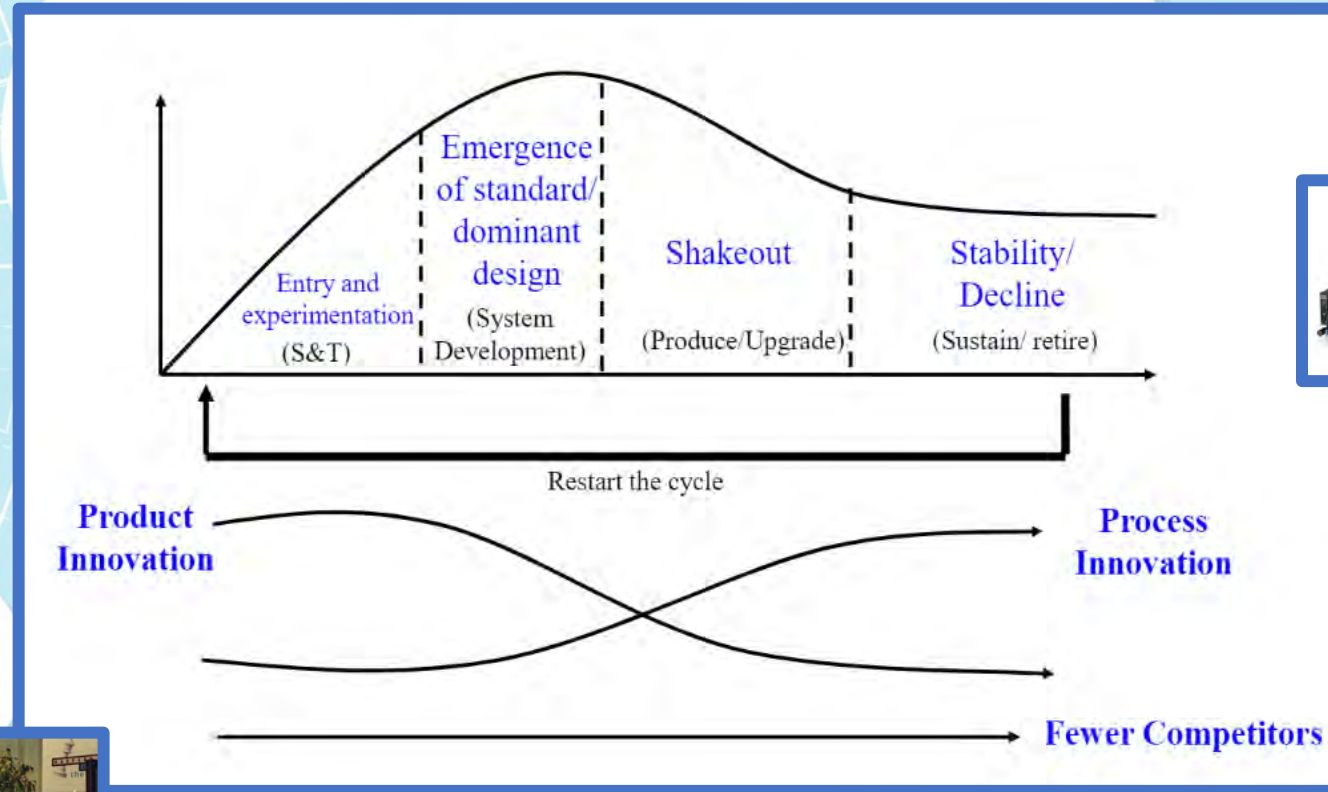
1981



1988



1996



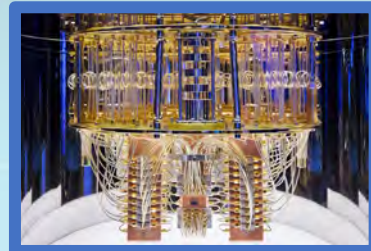
2005



2011



2023



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Digital Industries Firm Brief



Damon Durall

Joe Trimble

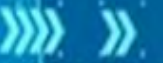
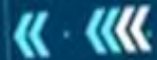
Borislav Genov

Nate Forrester

SIEMENS

Agenda

- Siemens Company Overview
- Digital Industries (DI) Overview
- DI Market
- DI & Porters Five Forces
- DI Porters Diamond
- DI Innovation
- DI Responding to Change
- Conclusion



Introduction

- History

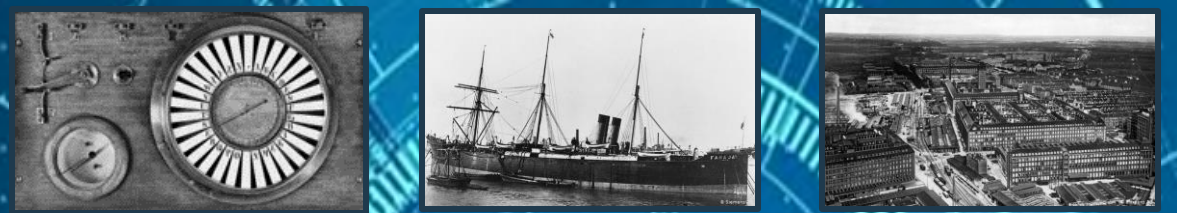
- 19th Century Founding
- 20th Century Expansion
- 21st Century Scandal and Refocus

- Divisions

- Digital Industries
- Smart Infrastructure
- Mobility
- Healthineers
- Financial Services
- Industrial Businesses

- Key Financials (2020)

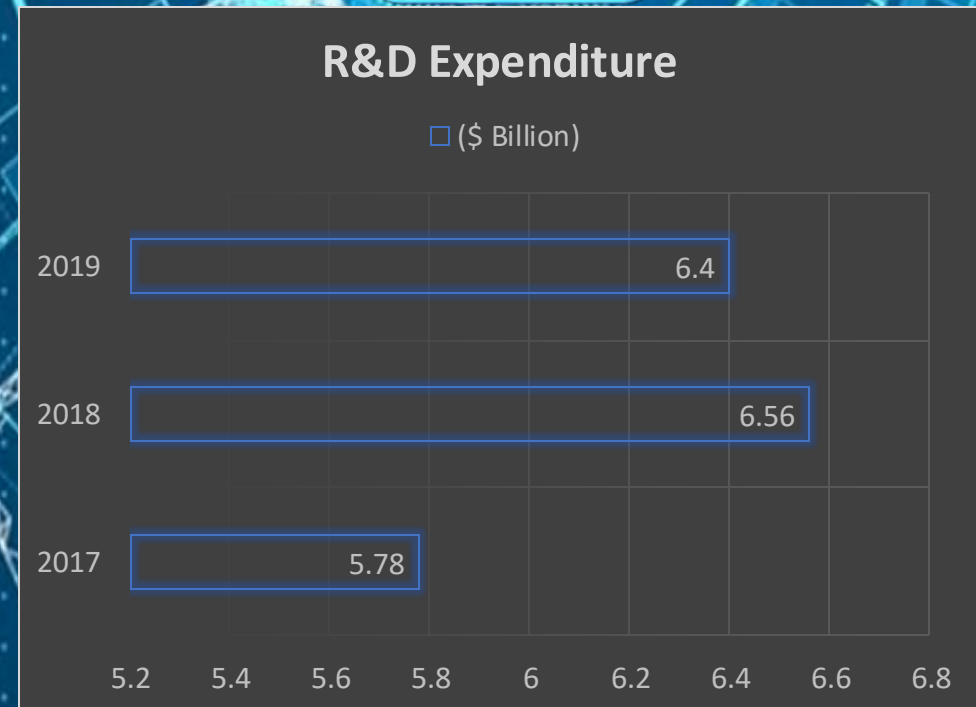
- Net Profits: \$4200m
- Capital \$123,897m
- Value Creation: ROIC 3.39% - 3.66% / WACC 5.14-7.60%
- Liquidity Risk: 1.55
- Solvency Risk: 1.04
- Debt to Equity Ratio: .937



Businesses				75% ²	
Digital Industries	Smart Infrastructure	Mobility	Siemens Advanta	Portfolio Companies	Siemens Healthineers ¹
71,700 Employees	69,600 Employees	38,500 Employees			54,300 Employees
€15.0bn Revenue	€14.3bn Revenue	€9.1bn Revenue			€14.5bn Revenue
21.7% Adjusted EBITA margin	9.1% Adjusted EBITA margin	9.1% Adjusted EBITA margin			15.1% Adjusted EBITA margin

Siemens Digital Industry

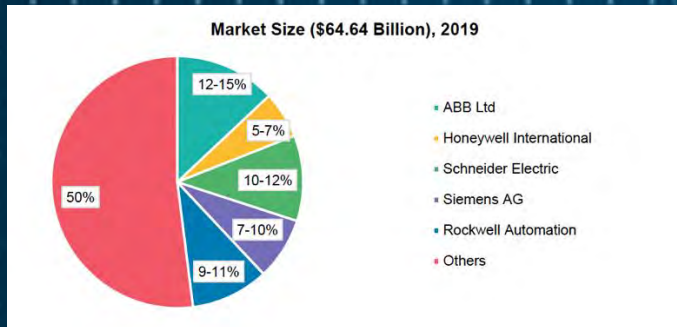
- Sector
 - Defining Industry 4.0
 - Automation Systems & Software
 - Connectivity & Communication
- Products & Services 
 - Operating & Control Systems
 - Software Analytics
- Business Model
 - Sell Products & Services
 - Provide Software and Analytics as a Service
 - Highly tailorable and a la carte
- Revenue
 - Revenue Mix
 - Revenue by Region
- R&D Expenditures



Honeywell



RA Rockwell
Automation



ABB



Schneider
Electric™

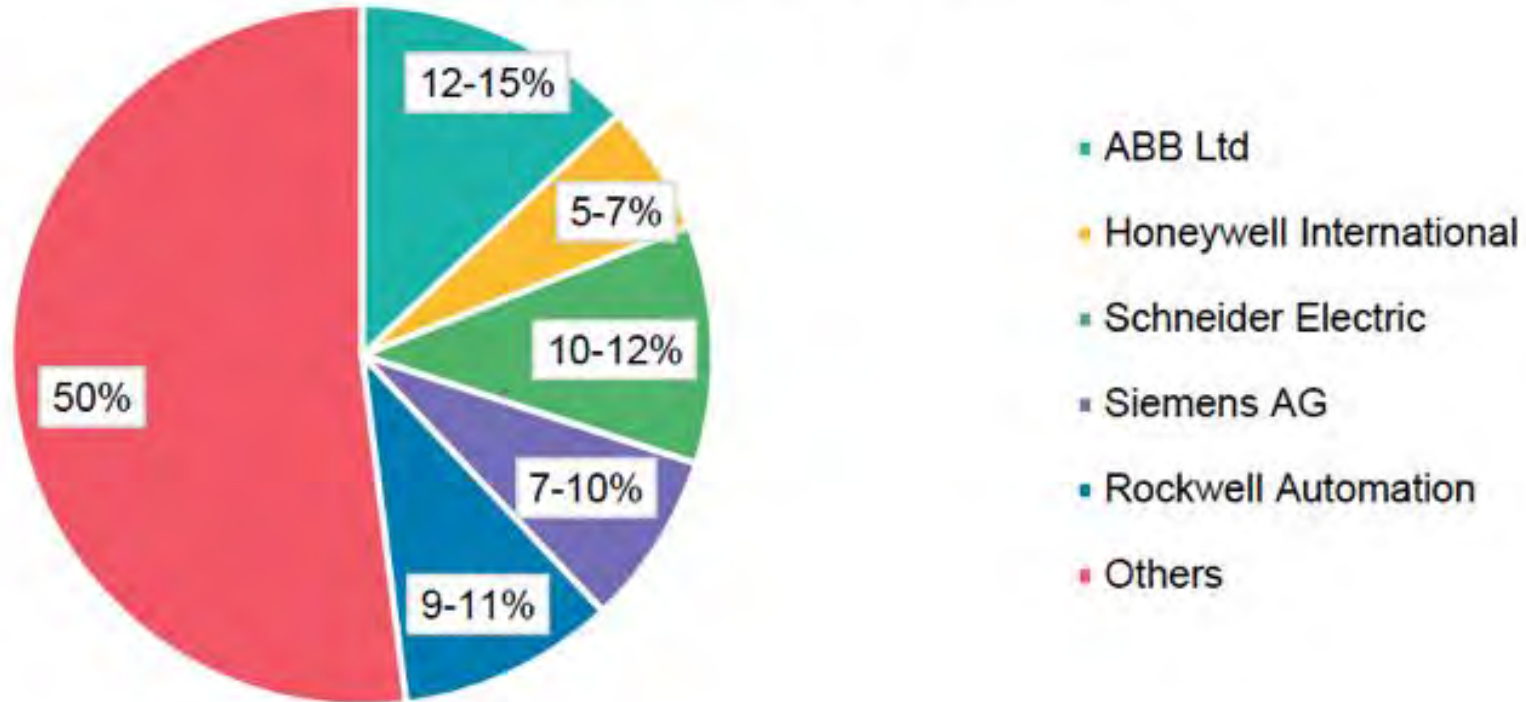
SIEMENS

Market Size and Competitors

Honeywell

Rockwell

Market Size (\$64.64 Billion), 2019



Size
itors

Schneider
Electric

SIEMENS

Firms' Value Creation

COMPANY	ROIC	WACC	CURRENT RATIO (LIQUIDITY)	DEBT-TO-EQUITY (SOLVENCY)
SIEMENS AG	3.66	5.14	1.56	1.17
ABB	2.40	5.12	1.25	0.45
HONEYWELL	10.94	7.90	1.47	1.32
ROCKWELL AUTOMATION	17.11	9.69	1.34	1.60
SCHNEIDER ELECTRIC	8.12	4.87	1.36	0.51
IBM	5.44	6.47	0.98	3.23

Source: GuruFocus.com, as of 3/30/21

Siemens Value, Liquidity & Solvency

Market Customers

Table 6.1: Global Smart Factory and Manufacturing Market (by End User), \$Billion, 2019-2025

Particulars	2019	2020	2021	2022	2023	2024	2025	CAGR (2020-2025)
Automotive	16.31	17.54	18.96	20.58	22.46	24.65	27.23	9.19%
Oil & Gas	7.98	8.50	9.11	9.80	10.60	11.53	12.62	8.22%
Pharmaceuticals	13.00	14.19	15.54	17.11	18.93	21.07	23.60	10.72%
Metal and Machining	5.97	6.33	6.74	7.21	7.76	8.40	9.15	7.65%
Food & Beverages	6.54	7.12	7.78	8.54	9.43	10.46	11.69	10.43%
FMCG	9.84	10.41	11.06	11.81	12.67	13.67	14.84	7.35%
Others	5.00	5.14	5.29	5.46	5.63	5.80	5.99	3.11%
Total	64.64	69.23	74.48	80.50	87.47	95.58	105.12	8.71%

Source: Expert Interviews, Secondary Research, and BIS Research Analysis

Market
Customers

Table 6.1: Global Smart Factory and Manufacturing Market (by End User), \$Billion, 2019-2025

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Pharmaceuticals	13.00	14.19	15.54	17.11	18.93	21.07	23.60	10.72%
Metal and Machining	5.97	6.33	6.74	7.21	7.76	8.40	9.15	7.65%
Food & Beverages	6.54	7.12	7.78	8.54	9.43	10.46	11.69	10.43%
FMCG	9.84	10.41	11.06	11.81	12.67	13.67	14.84	7.35%
Others	5.00	5.14	5.29	5.46	5.63	5.80	5.99	3.11%
Total	64.64	69.23	74.48	80.50	87.47	95.58	105.12	8.71%

Source: Expert Interviews, Secondary Research, and BIS Research Analysis

Market Customers

Table 6.1: Global Smart Factory and Manufacturing Market (by End User), \$Billion, 2019-2025

Particulars	2019	2020	2021	2022	2023	2024	2025	CAGR (2020-2025)
Automotive	16.31	17.54	18.96	20.58	22.46	24.65	27.23	9.19%
Oil & Gas	7.99	8.58	9.11	9.88	10.88	11.53	12.62	8.22%
Pharmaceuticals	13.00	14.19	15.54	17.11	18.93	21.07	23.60	10.72%
Metal and Machining	5.97	6.33	6.74	7.21	7.76	8.40	9.15	7.65%
Food & Beverages	6.54	7.12	7.78	8.54	9.43	10.46	11.69	10.43%
FMCG	9.84	10.41	11.06	11.81	12.67	13.67	14.84	7.35%
Others	5.00	5.14	5.29	5.46	5.63	5.80	5.99	3.11%
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Total	64.64	69.23	74.48	80.50	87.47	95.58	105.12	8.71%

Source: Expert Interviews, Secondary Research, and BIS Research Analysis

Defense Applications:

--Lockheed F-35 designed with digital thread technology; Using Siemens Teamcenter
--Siemens Teamcenter Software to be basis of Air Force

Defense Contractors are lagging behind in uptake of Industry 4.0. -*Deloitte*



Teamcenter software from Lockheed Martin helps keep hundreds of F-35 aircraft suppliers on the same page

FORT WORTH, Texas, 11 Feb. 2010. Leaders of the Lockheed Martin F-35 Joint Strike Fighter program are partnering with U.S. and international aerospace leaders, including Northrop Grumman and BAE Systems. These three primary partners are supported by up to 600 suppliers. In all, the parties involved in the production of the F-35 reside in more than 30 countries, spanning 17 time zones.

Reston, VA, USA, 26 January 2021

U.S. Air Force to Standardize on Siemens' Teamcenter as its Product Lifecycle Management Platform



Relevance for Great Power Competition: Siemens and Industry 4.0 by Region and Country

Table 7.1: Global Smart Factory and Manufacturing Market (by Region), \$Billion, 2019-2025

Particulars	2019	2020	2021	2022	2023	2024	2025	CAGR (2020-2025)
North America	9.18	9.75	10.40	11.14	12.01	13.02	14.20	7.82%
Europe	14.93	15.86	16.93	18.16	19.58	21.24	23.20	7.90%
Asia-Pacific	39.18	42.16	45.58	49.51	54.07	59.38	65.65	9.26%
Rest-of-the-World	1.35	1.46	1.57	1.69	1.81	1.94	2.07	7.26%
Total	64.64	69.23	74.48	80.50	87.47	95.58	105.12	8.71%

Source: Expert Interviews, Secondary Research, and BIS Research Analysis

Siemens in:	China	United States
Personnel	35,000	40,000
Sites	21	All 50 States
Revenue	\$8.4 billion	\$27 billion
Industry 4.0 Activities	Demonstrations, Cyber, R&D, Standards, Workforce	Cyber, Demonstrations, Workforce

U.S. vs China Industry 4.0

Figure 7.13: China Smart Factory and Manufacturing Market, \$Billion, 2019-2025



Source: Expert Interviews, Secondary Research, and BIS Research Analysis

Figure 7.3: The U.S Smart Factory and Manufacturing Market, \$Billion, 2019-2025



Source: Expert Interviews, Secondary Research, and BIS Research Analysis

**Threat of
New Entry**

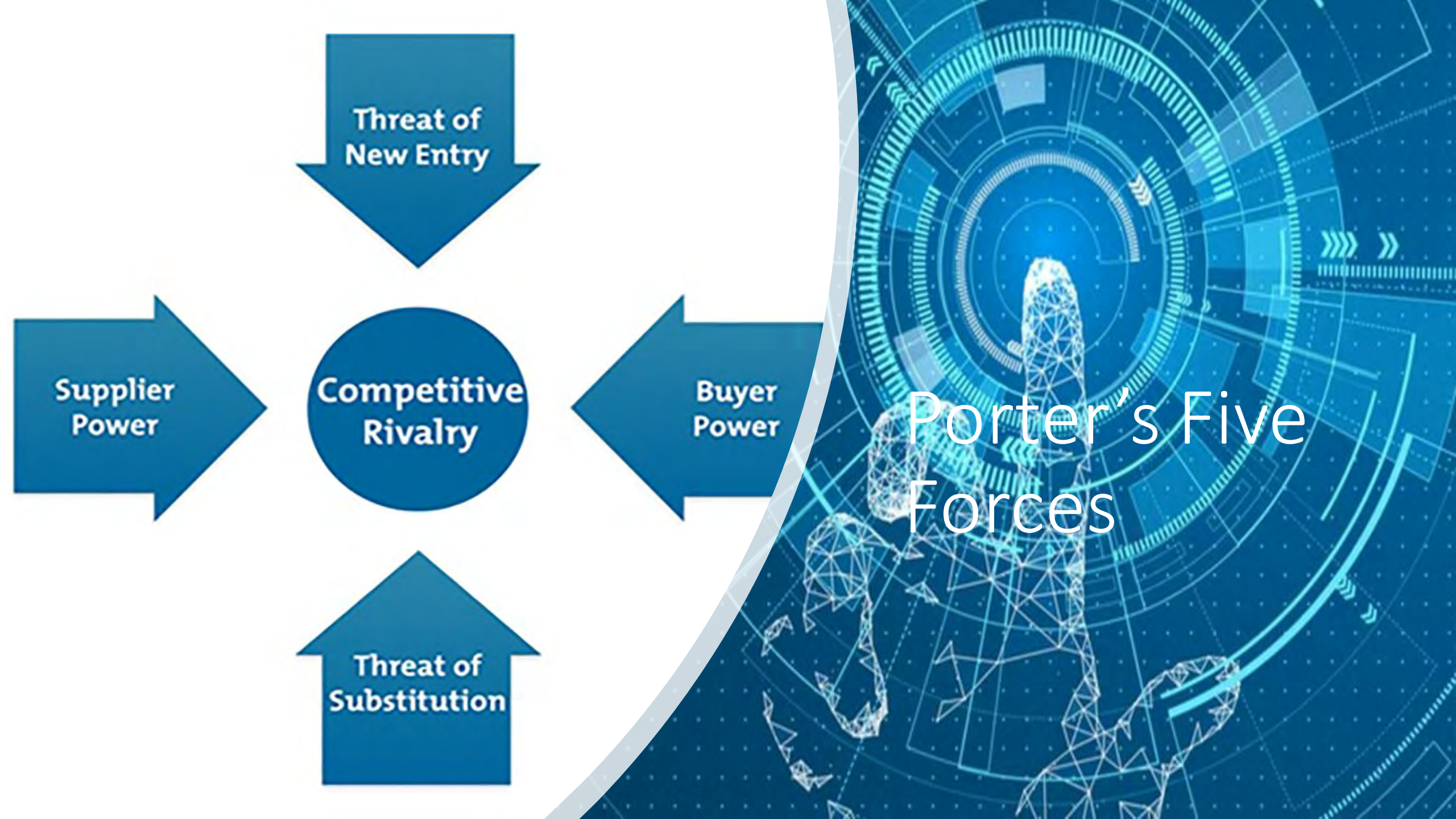
**Supplier
Power**

**Competitive
Rivalry**

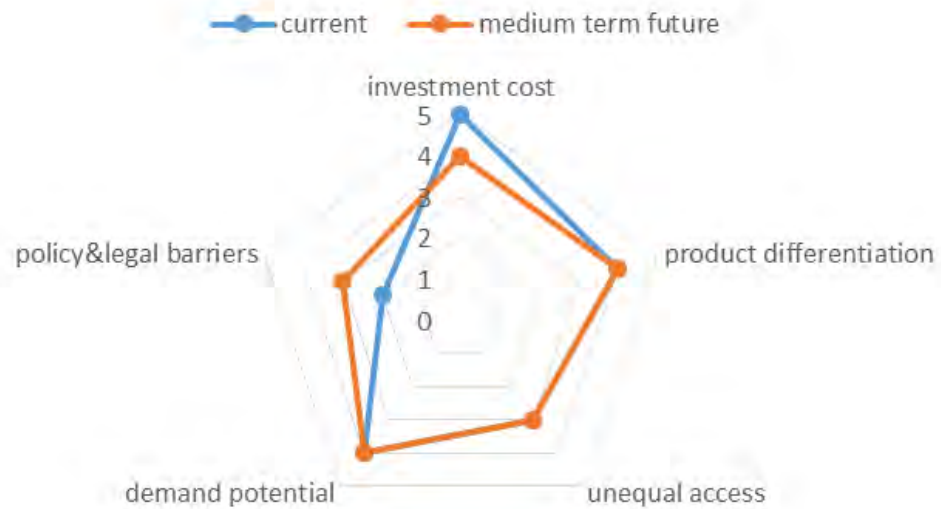
**Buyer
Power**

**Threat of
Substitution**

Porter's Five Forces



Threat of new entrants



Threat of New Entry

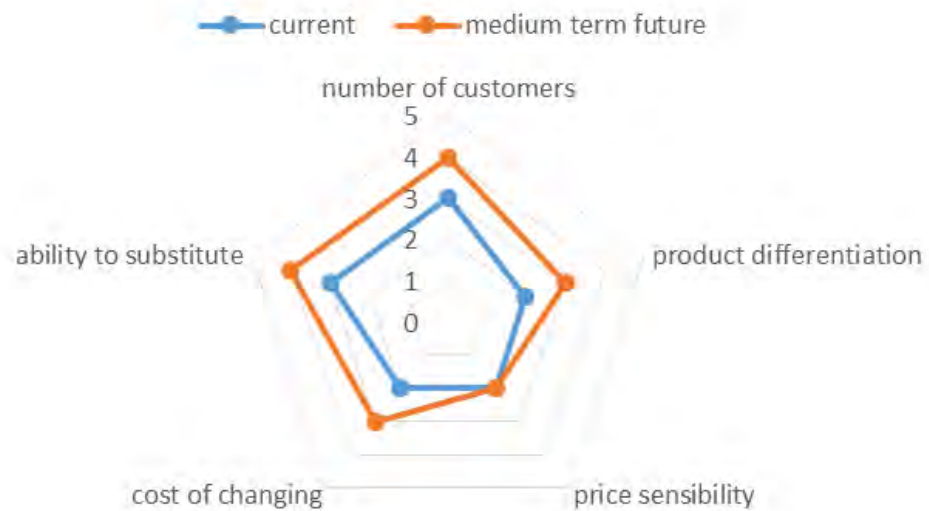
investment cost
product differentiation
unequal access
demand potential
policy & legal barriers



Competitive Rivalry

number of customers
product differentiation
price sensibility
cost of changing
ability to substitute

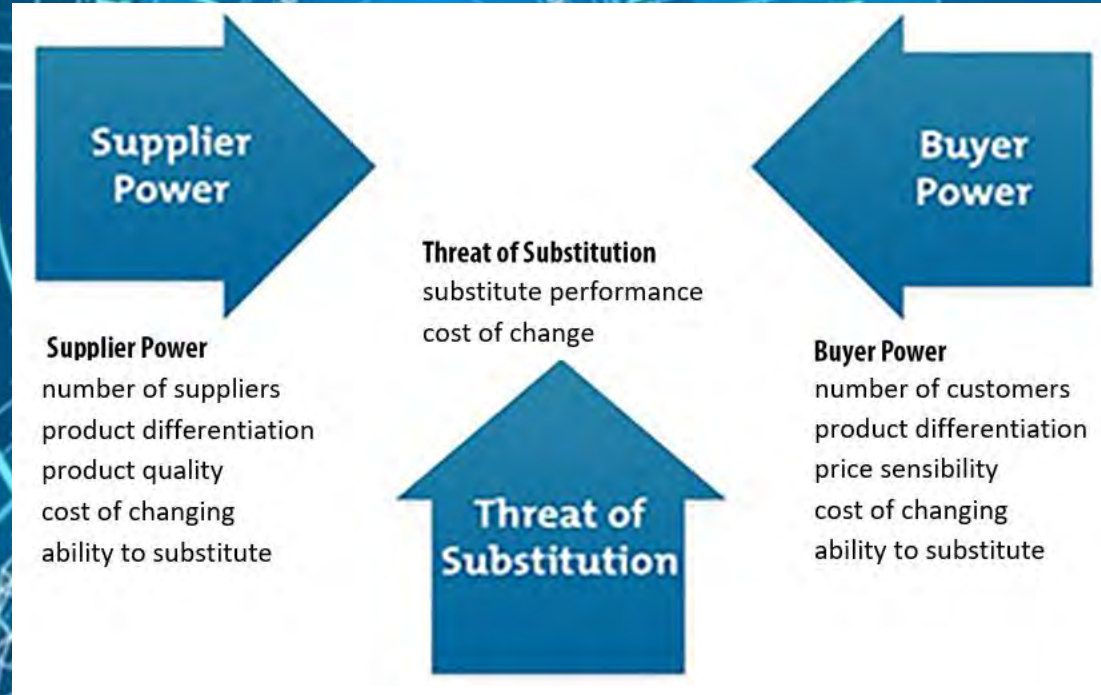
Competitive rivalry



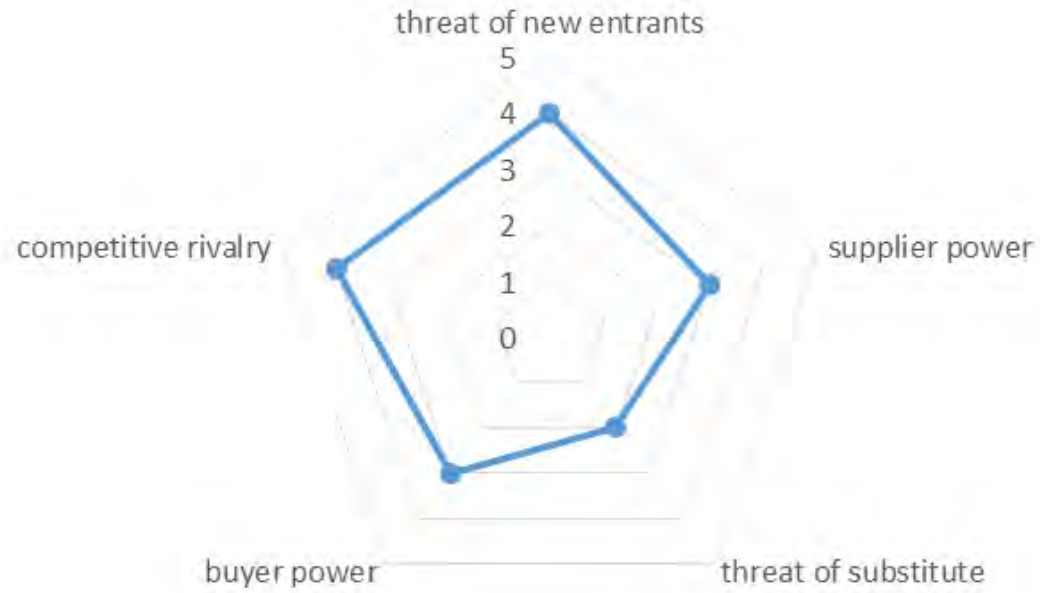
Supplier power



Buyer power



Importance of forces



Vision 2020+

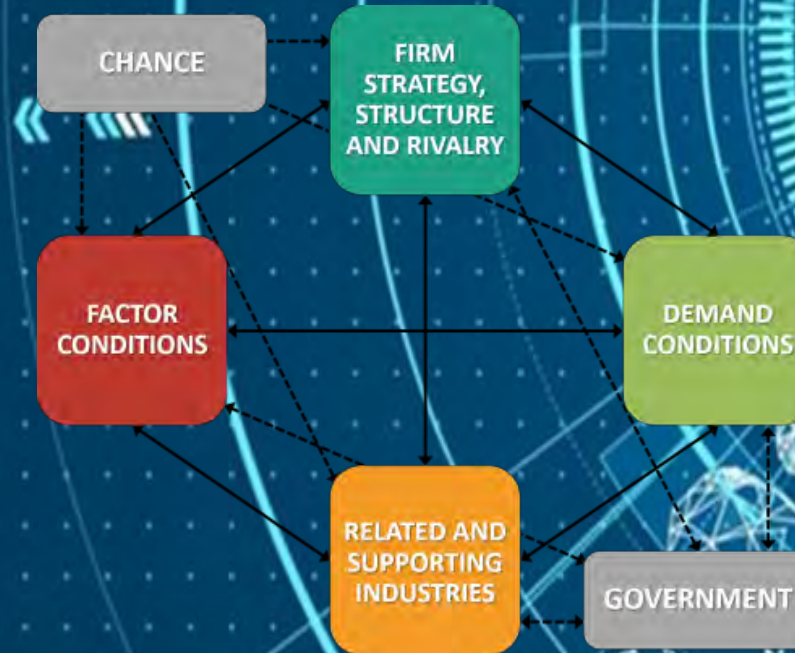
The firm's strategy

Porter's Diamond Assessment: US & China

The Competitive Advantage is A Tale of Two Cities

Firm Strategy & Rivalry	US	CHINA
Economic Reforms & Policy	X	X
Market Position	X	X
Business Model	X	X

Factor Conditions	US	CHINA
Human Resources	X	
Capital Resources		X
Admin Infrastructure	X	
IT Infrastructure	X	
S&T Infrastructure	X	



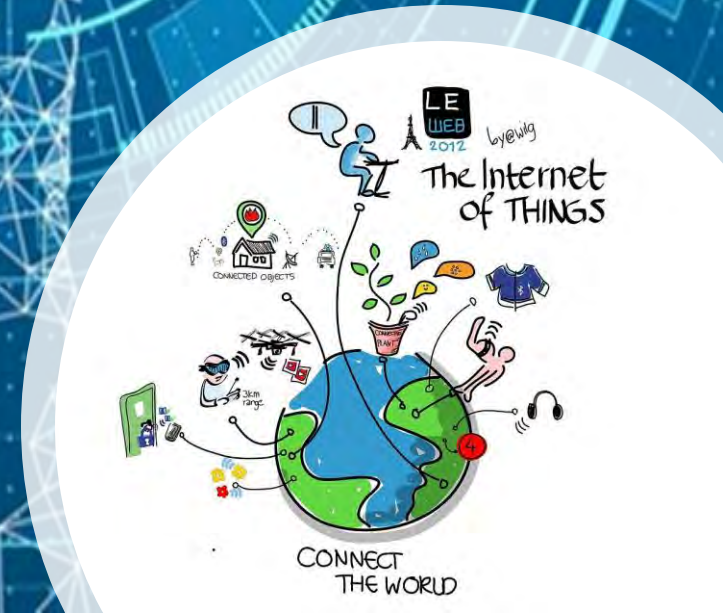
Demand Conditions	US	CHINA
Increase in Income	X	X
Demographics	X	
Stable Share of Secondary Industries	X	
Distance of Manufacturing Zones	X	
Age of Industries	X	

Related & Supporting Ind.	US	CHINA
Access to Suppliers & Firms In Related Fields	X	X
Potential Customers		X
Competitors	X	X
Presence of Clusters	X	X

Government & Chance	US	CHINA
Role of Govt.	X	X
Role of Chance		X
Weakness of Analysis	X	X

Digital Industry's Innovative Evolution

- The digital industry has undergone more change in the last five years than in the previous century
- Digitalized and highly automated production
- integrating future technologies
- Help customers accelerates transformation & overcome functional siloes
- Synergize product lifecycles, design, simulation, Industrial Internet of Things, and Cloud



Digital Industry Supply Chain

- Easy-to-use, secure platform for collaborating with suppliers
- Siemens' solutions support multiple-use cases including design data exchange, direct materials sourcing, and supplier program management
- Allows manufacturers and suppliers to maintain tight integration and real time feedback loops in the digital thread connecting people, processes, and data at scale globally



China's Influence

- For 147 years since its entering into China in 1872, Siemens has pioneered cooperation with the country with its solutions, technologies and products.
- Siemens generates annual revenue of 8.1 billion Euro in China, with over 34,000 employees, 21 R&D hubs, more than 5,000 R&D and engineering staff, and around 13,000 active patents and patent applications in China.
- Supply chain disruption in Asia due to COVID influenced Siemens' business performance in Fy20. Able to keep production largely stable due to the use of own technology in factories and diversified value chain.



Human Capital Domain

- Competition for diverse and highly qualified personnel (e. g. specialists, experts, digital talent) remains intense in the industries and regions in which our businesses operate
- Siemens' talent assessment methods enable it to hire people who adapt to the unpredictable ways the organization, roles and industry change
- Improve retention by identifying those who are fit for the future, while increasing greater talent mobility opportunities with access to global candidates
- The new solutions meant Siemens was greater prepared for the Covid-19 pandemic



National Security Interests and Policies

- Digital Twin does more than designing, analyzing and processing; It's the cyber-attack combatant!
- Surge and Mobilization would require Siemens to add human resources and hardware
- U.S. governments at all levels can use educational, immigration, and fiscal incentives to incent companies to invest and prepare for surge and mobilization events
- Bring Germany into Security of Supply Agreements and the National Technology and Industry Board



Questions?

