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Industry by Industry: More Chinese Mercantilism, Less Global Innovation

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China's long-standing and rampant "innovation mercantilist" policies harm global innovation by taking market share and revenues from more-innovative foreign competitors, thereby diminishing the resources they can invest in research and development toward further innovation.

KEY TAKEAWAYS

- In most industries, Chinese firms operate far from the frontier of innovation. To the extent China's mercantilist policies erode market share and reduce revenue for innovation leaders, they also reduce investment in the next round of innovation.
- Most scholarly, econometric studies on the impact of China's economic policies on foreign research and development (R&D) and innovation find a negative relationship.
- ITIF compiled case studies of five industries: solar panels, high-speed rail, telecom equipment, semiconductors, biopharmaceutical products. In each case, our economic models suggested significant negative impact on global R&D and patenting.
- In the semiconductor industry alone, ITIF found that if Chinese firms had 80 percent less market share, there would be 5,000 more U.S. patents annually.
- If China were to reduce its unfair mercantilist policies, the pace of global innovation would increase. But in a classic win-lose dynamic, China shows no inclination to do so.
- Allied nations should pressure China to reduce its harmful policies and encourage the WTO to focus more on the innovation effects of trade distortions.
- To apply pressure, allies should limit market access for innovation-based goods and services that are supported by Chinese government and its mercantilist policies.
- Allies also should cooperate more on technology policy and establish stronger trade agreements to allow for the free flow of innovation-based goods.

INTRODUCTION

It has become clear to even the most committed free traders that China is not engaged in anything approaching free trade, especially with regard to its technology sectors, such as telecommunications equipment, aircraft, pharmaceuticals, and semiconductors. While some dismiss the effects and effectiveness of China's advanced industries policies, many acknowledge their deleterious effects on U.S. production and jobs.

But what has largely been unappreciated, at least in policy circles, is the effect of China's policies and practices on global innovation. Robust technological innovation is the single greatest driver of higher living standards, better health outcomes, better quality of life, and a cleaner planet. As such, anything that slows the rate of global innovation should be seen as a challenge to all humanity.

China's long-standing and rampant "innovation mercantilist" policies harm global innovation largely by taking market share and revenues away from more-innovative foreign competitors, thereby diminishing their innovation capabilities. To be sure, some of China's policies have been legitimate and consistent with World Trade Organization (WTO) principles, such as funding university research and supporting STEM (science, technology, education, and math) education, and these policies contribute to global innovation. But most of China's innovation policies are mercantilist in nature and have reduced global innovation. As China seeks to win in even more advanced-technology industries, its policies will likely have an increased negative effect on innovation unless market-oriented, rule-of-law nations take stronger action.

Logic alone suggests that China's policies have harmed innovation because, in most industries, Chinese firms operate far from the global innovation frontier, so to the extent these policies reduce market share for innovation leaders, they also reduce those leaders' revenues, making it harder for them to invest in the next round of innovation.[1] Moreover, firms in innovation industries depend on intellectual property (IP) protection, so if Chinese firms can get access to their IP without paying, those innovators' returns from research and development (R&D) are reduced.

As China seeks to win in advanced-technology industries, its policies will likely have an increased negative effect on innovation unless market-oriented, rule-of-law nations take stronger action.

With support from the Smith Richardson Foundation, the Information Technology and Information Foundation (ITIF) conducted a research project to assess the impact of China's policies on global innovation, including a review of scholarly research examining this issue and case studies of five technology-based industries.

Both the economic studies and the case studies demonstrated that the logical hypothesis is correct: While at least two scholarly studies found that Chinese competition spurred innovation in other nations, the majority, including ones that critique these earlier studies, found the effect of Chinese economic growth and trade expansion was negative for innovation in most developed nations—particularly in North America and Europe.

ITIF found the same result with the case study analyses of five industries: telecommunications equipment, high-speed rail, solar panels, biopharmaceuticals, and semiconductors. The impacts in the latter two industries are more prospective because of the relatively small Chinese market share, but the impacts in the first three are quite sizeable. For example, in telecom equipment, the leading non-Chinese equipment companies (i.e., Ericsson, Nokia and Samsung) invest more in R&D, and patent and contribute more to international standards when compared with Huawei and ZTE, when controlling for sales and size. Without unfair Chinese policies (such as forced tech transfer for market access, blocked Chinese market access, IP theft, and government funding of product development), Huawei and ZTE would barely exist. By artificially taking market share from more innovative companies, the latter have had less revenue to invest in cutting-edge R&D. In fact, if Ericsson and Nokia took all of Huawei and ZTE sales, there would be 20 percent more global telecom equipment R&D and 75 percent more essential 5G patents.[2] We see the same dynamic in solar panels and high-speed rail, wherein the less innovative took market share from more-innovative foreign firms.[3] We even see it in the semiconductor industry, wherein ITIF found that if Chinese firms had 80 percent fewer sales, there would be more than 5,000 more United States Patent Office (USPTO) semiconductor patents annually.[4]

To be clear, this is not to say that everything China does in this space is harmful to global innovation. As we note with regard to solar panels, it appears that while Chinese subsidies and import barriers harm product innovation, because of the scale achieved by Chinese producers, they likely spur process innovation.[5] Likewise, Chinese legitimate innovation policies, such as supporting early-stage research and encouraging STEM graduates, likely help global innovation. But on net, China's single-minded goal to become the world innovation leader by using a vast array of unfair practices comes at the expense of global innovation.

THE NATURE OF CHINA'S INNOVATION MERCANTILISM

Despite China's agreement to join WTO in 2001, it has never fully taken those obligations seriously, especially over the last decade as the Chinese government has doubled down on unfair and mercantilist practices targeting advanced sectors.[6]

This first became evident in 2006, when China pivoted from an economic development strategy that sought principally to induce foreign multinationals to shift production to China to a "China Inc." model of "indigenous innovation" that focused explicitly on supporting Chinese enterprises, often at the expense of foreign ones. Marking this shift was a seminal document called the *National Medium- and Long-Term Program for Science and Technology Development (2006–2020)*, or "MLP," which called on China to master 402 key technologies, from intelligent automobiles to integrated circuits and high-performance computers. China doubled down on this with its later "Made in China, 2025" program that targeted eight key technologies for massive government support.

At the heart of China's strategy is foreign technology acquisition. The Chinese leadership knows that if it just relies on market forces, few if any foreign technology leaders will provide them with the technology Chinese firms need. And domestic Chinese firms, while making progress, lag behind the global technology leaders. As a result, China has deployed a panoply of tools to unfairly and often illegally obtain needed foreign technology. And once it obtains that technology, it relies on an array of tools, including protected markets and massive subsidies, to scale up and gain global market share.

China deploys an array of unfair, innovation mercantilist policies.

Intellectual Property Theft

IP theft is an important tool in the Chinese arsenal, with China having deployed industrial spies to obtain foreign secrets. Another vector is cyber theft. Seven percent of U.S. firms operating in China list cyber theft as a problem—a number that presumably would be higher if every firm that had faced an intrusion were aware of it.[7] Then National Security Agency (NSA) director Keith Alexander called Chinese IP theft "the greatest transfer of wealth in history."[8] Another vector for purloined IP is to trick companies in the United States into thinking that a Chinese firm wants to invest in them, and then through the process of due diligence, the Chinese learn that company's trade secrets. Another path is through exchange visits and student enrollments in U.S. universities.[9]

Table 1: Assessing China's innovation policies on global innovation

Type of Policy	Impact on Global Innovation
Funding and sharing of technology development with Chinese firms	Harmful
Forced technology transfer	Harmful
Intellectual property theft	Harmful
Currency manipulation	Harmful
Export financing above OECD guideline levels	Harmful
Tariffs	Harmful
Government-allocated domestic market shares to Chinese firms	Harmful
Political hardball for access to foreign markets	Harmful
Support of foreign corrupt business practices	Harmful
R&D tax incentives (favorable to Chinese firms)	Neutral
R&D subsidies (favorable to Chinese firms)	Neutral
Low-cost financing (for Chinese firms only)	Neutral
Limited export control regime	Neutral
Support of STEM education	Helpful

Weak IP Protection

Weak enforcement of IP law is another vector. Chinese firms can often copy and reengineer foreign technologies with impunity (what they call "introducing, digesting, absorbing, and re-innovating")—even those technologies protected by patents. As an *MIT Sloan Management Review* article, "Protecting Intellectual Property in China," notes, "Intellectual property protection is the No. 1 challenge for multinational corporations operating in China."[10] The Chinese patent office also favors domestic over foreign patent applicants in strategic industries.[11]

State-Backed Purchases of Foreign Technology Companies

Chinese firms regularly gain access to needed technology by buying up foreign technology companies or investing in high-tech start-ups, which both the recent enactment of the Foreign Investment Risk Review Modernization Act (FIRRMA) and aggressive efforts by the Trump

administration have succeeded in limiting, at least with acquisitions. But Chinese government-backed firms continue to try to do this in other advanced economies, particularly Europe.

Forced Technology Transfer

China routinely requires firms to transfer technology in exchange for being granted the ability to invest, operate, or sell in China.[12] Because such conditions usually contravene China's WTO commitments, officials are careful not to put such requirements in writing, usually resorting instead to oral communications to pressure foreign firms to transfer technology.[13] The Chinese term for this is "exchanging market for technology."[14]

Protected Domestic Markets

One of the biggest unfair advantages Chinese firms often enjoy is having the massive and rapidly growing domestic market almost completely to themselves. The large and growing Chinese market plays a key role in enabling these firms to gain scale and boost innovation so they can then take on foreign firms in foreign markets. For example, Chinese governments favor Chinese-company-produced drugs for its hospital systems and requires drug import licenses, which can be difficult to obtain, that are issued for only for five years—and renewals are not guaranteed.

The Chinese government also imposes import tariffs on a variety of industries. Meanwhile, under the WTO Pharmaceutical Agreement—to which China is not a party—the United States does not impose tariffs on biopharmaceutical products. For instance, China's drug imports are subject to a 5 to 6 percent import tariff.

Discriminatory Procurement

The Chinese government also uses discriminatory procurement practices to favor Chinese-owned firms. In 5G equipment, it lets foreign firms have only a de minimis share of the market such that these foreign firms are forced to push back against home-region efforts to fight unfair Chinese policies, knowing that failing to do so would result in even less access.

Government-Backed Venture Capital Investing

While many governments support venture investing, just as they support export financing, China's investments are massive. At the end of 2017, there were a recorded 1,166 government-led venture funds, up from 214 funds in 2013, with 5.3 trillion yuan ($780 billion) in targeted capital. These government-backed VC funds are targeted to industries deemed strategic by the Chinese government.

State-Owned and Backed Enterprises

Chinese governments also influence the industry structure through state ownership, which gives Chinese firms innumerable advantages such as lower business taxes, low-cost loans, and reduced regulatory scrutiny.

Subsidies to Chinese Firms

Chinese governments (national, provincial and local) provide massive subsidies to the country's advanced technology firms. This involves grants, tax exemptions, and low-interest loans. Once firms have the technology, competencies, and scale to go global, the government then often subsidizes global market expansion, such as through the China Export-Import Bank and China's Export and Credit Insurance Corporation (Sinosure).[15] These subsidies not only help the recipients directly, but are often tied to buying Chinese components. For example, in the high-

end equipment manufacturing sector, China maintains a program that conditions the receipt of a subsidy on an enterprise's use of at least 60 percent Chinese-made components when producing intelligent manufacturing equipment.[16]

As George and Usha Haley documented in their book, *Subsidies to Chinese Industry: State Capitalism, Business Strategy, and Trade Policy*, China's game plan has long been to "aggressively subsidize targeted industries to dominate global markets." In the 2000s, China provided almost $100 billion in subsidies to just three industries alone: $33 billion for paper, $28 billion for auto parts, and $27 billion for steel.[17] China's share of global solar-panel exports grew from just 5 percent in the mid-2000s to 67 percent today, with Chinese solar output turbocharged by at least $42 billion in subsidies from 2010 to 2012 alone.[18] China now wants to replicate this strategy in other advanced-technology industries, such as semiconductors and electric batteries.[19] For instance, China's National Integrated Circuit (IC) Strategy calls for at least $160 billion in subsidies to create a completely closed-loop semiconductor industry in China, including explicit plans to halve Chinese imports of U.S.-manufactured semiconductors by 2025 and eliminate them entirely by 2035. The "Made in China 2025 Strategy" is supported by some 800 state-guided funds to the tune of more than $350 billion, including advanced-battery manufacturing, wide-body aircraft, and robotics.

THE LOGIC FOR INNOVATION HARM

China's policies seek to expand global market share for Chinese companies, and to the extent they succeed, this enhances competition in the relevant markets, unless the effected firms go out of business.

Economic theory suggests that such enhanced competition could have two effects. It could spur affected firms to "pedal faster" and try to innovate more as a way escape the competition, or it could eat into revenues, thereby limiting the ability of the affected firms to reinvest in R&D and advanced production.

Some economists, notably Kenneth Arrow, contend that innovation would be greater in more competitive markets.[20] In contrast, Joseph Schumpeter argued firms with temporary market power from innovation (e.g., a patented product) would have both the resources and the incentive to innovate further. Firms with little market power and "normal" (e.g., low) rates of profits would not have the resources to effectively innovate.

One way to square this circle comes from scholars who argue the relationship between competition and innovation resembles an inverted "U."[21] When a market is dominated by one or two firms, and the firms have the revenues to invest in innovation but lack the competitive pressures to do so, innovation is hindered. In contrast, in fragmented and hypercompetitive markets, firms tend to produce less innovation because, while they have the competitive motivation, they lack the revenues from superior profits to invest in costly R&D.

How China might affect foreign-firm innovation depends in part on where industries are on the inverted U. If industries are on the right side of the U, then more competition from trade might very well spur more innovation. In contrast, if they are at the peak or on the left side, more competition might reduce innovation. Few if any of the advanced industries China has targeted, however, have been characterized by oligopolistic market conditions, and even where this is the case (e.g., aerospace), competition has been intense.

Since most industries have been on the left side of the curve, unfair Chinese competition is likely to have reduced innovation by not only reducing the size of the market for the innovative firms (e.g., closing off the Chinese market) but also by reducing their sales in other markets. This matters because innovation industries usually have high fixed costs for design and development, but relatively low marginal costs for production. In other words, the cost of the first product is extremely high, while subsequent items are much less costly. In these industries, larger markets better enable firms to amortize those fixed costs over more sales, so unit costs can be lower and revenues for reinvestment in innovation higher. Firms in most innovation industries are therefore global. If they can sell in 20 countries rather than just 5—thereby expanding their sales by a factor of 4—then their costs increase disproportionally less.

Trade barriers and distortions can limit scale economies if they limit market access to foreign firms in favor of domestic firms, and raise total global innovation costs by enabling more firms than necessary. Unfair competition also limits innovation by reducing revenues and profits needed to reinvest in the next generation of innovation. As Carl Shapiro noted, "Innovation incentives are low if ex-post competition is so intense that even successful innovators cannot earn profits sufficient to allow a reasonable risk-adjusted rate of return on their R&D cost."[22] Finally, IP protection enables firms investing in innovation to make enough returns over a fixed period of time to recoup their costs and more, while at the same time enabling information disclosure. As such, weak IP protection, state-sanctioned IP theft, and other forms of non-market-based technology transfer weaken innovation.

This is not to advocate for a strict free-market orientation that sees all government policies for innovation support as inherently distortionary and mercantilist. To be clear, government innovation policies can be pro-innovation if they help innovative firms overcome particular challenges. For example, public-private research partnerships, such as the Fraunhofer Institutes in Germany, are a case in point. But these institutes, designed to help firms in an industry solve complex technical challenges, are different than mercantilist policies subsidizing or protecting particular firms that otherwise would exit the market. Indeed, an exhaustive literature shows domestic policies—including support for a robust science and engineering workforce, an entrepreneurial culture, public investment in research, and favorable tax treatment of R&D—all support innovation, and can correct for identifiable market failures.[23] However, while some nations focus on fair and non-distortive domestic innovation policies, many, especially China, default to innovation mercantilist policies.[24]

In other words, to assess the impact of foreign firms and economies on innovation, one needs to determine where on the inverted U the competition exerts itself. It is likely "normal" global competition, supported by market-consistent government innovation policies, exerts itself on the left side of the inverted U and improves innovation, both by spurring a more-competitive response among incumbents and generating an innovation-based division of labor with developed nations specializing more in innovation-based activities. In contrast, innovation mercantilist competition likely exerts itself on the right side of the inverted U and harms innovation.

To be sure, innovation policies could spur global innovation in a number of circumstances. First, if Chinese firms are more innovative—and by unfairly taking market share from less-innovative foreign firms, they gain even more revenues to invest in innovation—then global innovation could

increase. But in all of the five case studies for this report, as well as in other industries examined (including shipbuilding and aerospace), the Chinese firms were technology laggards.

Second, Chinese policies could spur global innovation if they supported factor conditions that spur innovation. These policies include funding basic and applied research, supporting STEM education, having a favorable tax code (e.g., R&D tax credits), and spurring technology commercialization among universities and government labs. To be sure, the Chinese government does all these things, although it invests more in applied R&D than it does in basic research that helps the world, and its tax credits discriminate against foreign firms. And even if these policies were designed in fair and globally oriented ways, would their net innovation benefits outweigh the net global innovation costs from the innovation mercantilist policies. Not only does it appear that the answer is no, but there is also no reason China couldn't just pursue fair, global innovation-enhancing policies and eschew its innovation mercantilist ones.

Third, it's possible that China's support for creating large markets and large producers spurs innovation, in part because of economies of scale, and also the role it can play in innovation. For example, China's policies to build out a massive high-speed rail network, install 5G networks, and incentivize the purchases of electric vehicles all help spur demand for innovative products, which in turn spurs innovation. But the key to ensuring that these kinds of demand-creation policies spur innovation is for the procurement to be nation-neutral and enable the most-innovative firms to win contracts. That is the exact opposite of what China has done in favoring its own, less-innovative firms.

In the last several years, a number of scholars have conducted econometric studies to examine the impact of Chinese competition on R&D and innovation in other, mostly Western, economies. Most, but not all, have found the effect was negative, harming innovation.

The support of large producers is a slightly different issues. Chinese policies have enabled some Chinese firms, such as Solar XX and Huawei to become very large. In the case of Chinese solar firms, large Chinese subsidies enabled them to become massive in size—and there is some evidence that this scale has enabled process innovation (e.g., innovation in how things are made). Again, China could have made these subsidies nation-neutral and declared that any firm, Chinese or foreign, that built a solar panel factory in China could receive these subsidies. This would have enabled economies of scale, albeit for firms that are more innovative than Chinese firms. Moreover, firms may focus less on process innovation when they move production to low-wage nations because it is easier to simply use low-wage labor than invest in process innovation (e.g., robotics) in their higher-wage home country.[25] Investments in process innovation become less valuable the lower the workers' wages.

EMPIRICAL STUDIES

In the last decade, a number of scholars have conducted econometric studies to examine the impact of Chinese competition on R&D and innovation in other, mostly Western, economies. Most, but not all, have found the effect was negative, harming innovation.[26]

Process Innovation

Process innovation refers to how companies produce a good or service. Chinese polices can affect this. Chinese lower-wage markets makes it easier for companies to shift or establish production there, and because labor is cheaper, it makes less economic sense to invest in automation.

Bena and Simintzi found that the 1999 bilateral trade agreement between the United States and China made investment in China more profitable and secure, but reduced process innovation investment in the United States by 25 percent over what it would have been absent the agreement.[27] A 2016 study by Kueng, Li, and Yang of effects on Canadian firms found the same result: "Canadian manufacturing firms systematically reduce[d] innovation activities … This reduction in innovative activities [was] strongly driven by a drop in process innovation rather than product innovation."[28]

One might argue these dynamics were just a process of global expansion and market opening, and this result was a net positive because of better factor allocation from free trade. But this is not the whole story. First, China manipulated the cost of production in order to keep it lower than market forces would otherwise have generated, likely resulting in the misallocation of resources, with a negative net effect on global welfare. Companies expanded low-wage, low-productivity production at the expense of higher wage, higher productivity production more than they would have otherwise.

Product Innovation

There have been a number of studies examining the impact of trade on innovation, with most focusing on the impact of China, especially in the 2000s. Some studies that looked more broadly at trade with developing nations—particularly prior to 2000—found a positive effect on innovation in the United States. When looking at the impact of China in the 2000s, several studies found China had a positive impact on EU and U.S. innovation, but most concluded the opposite: China hurt innovation in the EU and United States. There may be several reasons for the conflicting findings, including different time periods of study, quantitative models, and datasets used.

Myeongwan Kim studied whether Chinese competition could help explain both the decline in business enterprise R&D and total factor productivity, also in Canada, after 2000 (China was accepted into WTO in December 2001).[29] He used Canadian firm-level data to explore the impact of rising Chinese import competition on Canadian firm R&D. Chinese imports as a share of domestic production increased from around 2 percent in 2000 to around 8 percent in 2010.[30] The study found "increasing Chinese import competition reduced R&D" within Canadian firms. The effect was most pronounced in smaller firms. It was also negative for large Canadian firms, but significant at the 10 percent confidence level (in other words, the range of values within which there is a 90 percent certainty the true mean of the population is found). Kim discovered competition from China explained about 7 percent of the total decline in R&D expenditures in Canadian manufacturing between 2005 and 2010 (a decline of around CA$92 million per year). Overall, the study estimated, on average, R&D expenditure growth within firms fell by 1.027 percentage points in response to a 1 percentage point increase in the Chinese import share in total domestic consumption. One reason for the decline in R&D is Chinese import competition reduced the profitability of Canadian manufacturing firms. It is important to note that this was during a period when a larger share of Chinese competition was in less-R&D-intensive

industries—and presumably, if the study had been able to focus on more recent data, the effects would have been considerably higher.

2017 research by Autor, Dorn, Hanson, Pisano, and Shu examined the impact of Chinese competition on U.S. patents in 2013. They noted at the time,

> [W]e document a robust, negative impact of rising Chinese competition on firm-level and technology class-level patent production. Accompanying this fall in innovation, global employment, sales, profitability, and R&D expenditure all decline within trade-exposed firms.[31]

They also found that "accelerating import competition from China during the 2000s can explain about 40% of the slowdown in patenting in 1999–2007 relative to 1991–1999."[32] On average, they concluded, firms reduce R&D investment when they belong to industries that are exposed to more import competition from China.

A number of other studies have found similar results for the U.S. economy. Akcigit, Ates, and Impullitti looked at the impact of China on U.S. innovation and found, "Even a relatively very advanced economy might experience a reduction in aggregate innovation, if it has an enough number of sectors that are getting discouraged by foreign competition."[33] They went on to note that "foreign technological catching-up hurts U.S. welfare by stealing away business and profits of U.S. firms."[34] Hombert and Matray found similar results, observing that "rising imports lead to slower sales growth and lower profitability for firms in import competing industries." However, this effect is significantly smaller for firms that have invested large amounts in R&D, thanks to more-generous state R&D tax credit policies.[35]

Firms reduce R&D investment when they belong to industries that are exposed to more import competition from China.

The evidence with regard to the impact on Europe is mixed. One highly cited study on the effect of Chinese trade on a number of northern European economies found Chinese trade stimulated innovation. Bloom, Draca, and Van Reenen studied the impact of Chinese trade on EU innovation from 2000 to 2007 and concluded, "China appeared to account for almost 15% of the increase in patenting, IT, and productivity."[36] They found, "Chinese import competition reduces employment and survival probabilities in low-tech firms."[37] In addition, "Firms with lower levels of patents or [total factor productivity] shrink and exit much more rapidly than high-tech firms in response to Chinese competition." However, "Chinese import competition increases innovation *within* surviving firms," especially firms that are more high tech (with higher patenting rates). One key question the authors failed to answer, in part because it is methodologically difficult, is whether these firms that went out of business are less innovative than their Chinese counterparts.

A later study of the impact on Europe found opposite results from Bloom et al. that are consistent with the results of most studies of impacts on firms in the United States. Campbell and Mau found,

> [T]he apparent positive impact of Chinese competition on European patenting [that Bloom et al. found] disappears once one controls for richer sectoral trends, the lagged level of

> patents, or switches to Chinese import penetration instead of the Chinese share of imports … Thus, we believe we have partially solved the puzzle of why the rise of China ostensibly had a negative impact on patents in the US (or, others have found no impact on R&D for the US), but a positive impact in Europe—the latter results appear to be spurious.[38]

Indeed, they discovered, "When controlling for lagged patents and outsourcing, and using Chinese penetration, one is more likely to get negative and significant coefficients."[39] They reached this finding in part because they used more robust methods, including more controls for spurious correlation, such as lagged patents trends and pretreatment levels.

CASE STUDIES

ITIF conducted five in-depth industry/technology case studies. The first three—telecommunications equipment, high-speed rail, and solar panels—are industries wherein China has made considerable progress in entering global markets. The other two— biopharmaceuticals and semiconductors—are more prospective in nature, as China still lags behind global leaders in these two industries.

Telecommunications Equipment

The telecommunications equipment industry serves wireless and wireline providers, including for voice, data, and video. The industry is technologically sophisticated, yet nowhere near mature. In the wireline industry, both switches and cabling regularly improve in speed and capacity. Each new generation of wireless technology—now moving into its fifth, known as 5G—brings order-of-magnitude improvements in wireless networks.[40]

There is no question that, without unfair innovation mercantilist policies and programs, China would lack a globally competitive telecom equipment industry. Neither Huawei nor ZTE, China's two national champions, would have more than de minimis market shares, even in China. Nor is there any question that Chinese market-share gains have come at the expense of innovative telecom equipment providers based in other nations. In the 2000s, Chinese innovation mercantilism contributed to the demise of Canada's Nortel and America's Lucent, the world's two most innovative telecom equipment producers in the late 1990s. And since then, China's rise has come at the expense of global market share and profits for Europe's Ericsson and Nokia, the number two and number three players in the industry, respectively.

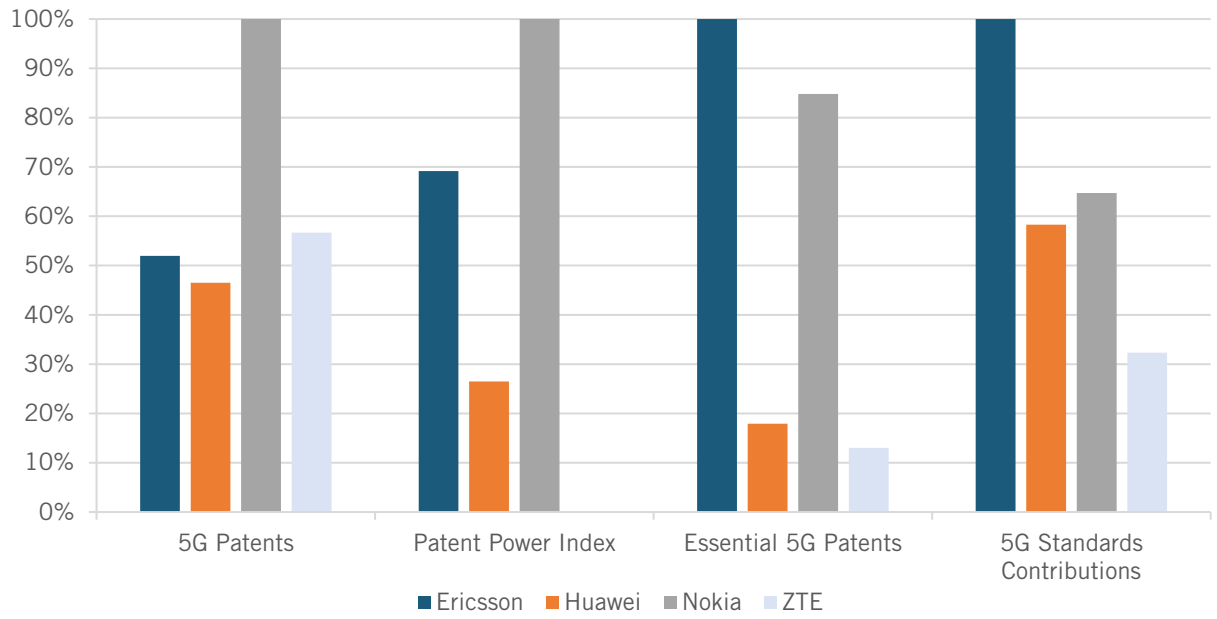
While it is impossible to definitively know the counterfactual on net, the evidence suggests there would be even more innovation today if Huawei did not exist: A greater number of innovative, non-Chinese firms would have more revenue to support more productive R&D.

The question of impact on innovation is more complicated. China's state backing of Huawei and ZTE allowed for the two of them to seize global market share from far more-innovative non-Chinese telecom equipment companies. It did this by severely limiting their competitors' access to both China's and related markets, and supporting Huawei's and ZTE's rapid expansion overseas. This has eroded non-Chinese companies' revenue growth, which has slowed the rate at which they can increase spending on R&D, thus slowing their pace of innovation from what it otherwise would be. Both Chinese companies, but particularly Huawei, invest heavily in R&D and generate a significant number of international patents. However, they patent less than their

global market shares would predict; and considering patent quality and other measures of innovation, such as accepted 5G standards, Ericsson and Nokia still remain significantly ahead of Huawei and ZTE, even after unfairly losing global market share.

So while Chinese innovation mercantilism appears to have either killed, contracted, or slowed the growth of innovative foreign telecom equipment companies, it has allowed Huawei and ZTE to emerge and grow, and thus innovate, though not at the same rate as leading non-Chinese counterparts do per dollar of sales. And while it is impossible to definitively know the counterfactual on net, the evidence suggests there would be even more innovation in the industry today if Huawei and ZTE did not exist: A greater number of innovative, non-Chinese firms would have more revenue to support more productive R&D. ITIF estimated that if Ericsson and Nokia took all of Huawei and ZTE telecom equipment sales, global telecom equipment R&D would increase 20 percent, 5G standards contributions would increase 18 percent, and essential 5G patents would increase 75 percent. In short, Chinese policies, and Chinese telecom equipment firms, on net, are a drag on global innovation.

Figure 1: Company scores on selected innovation indicators as a share of the leading company score[41]



Without unfair Chinese government policies, more-innovative companies would have had more revenue to invest in cutting-edge R&D. ITIF estimated that, in fact, if Ericsson and Nokia took all of Huawei and ZTE sales, there would be 20 percent more global telecom equipment R&D and 75 percent more essential 5G patents.[42]

High-Speed Rail

High-speed rail is a technology-driven sector that has taken decades for the leading Japanese and European firms, and the broader ecosystem of component suppliers in the United States and elsewhere, to master. Yet, at some point during the last 20 years, China used mercantilist policies to rapidly and unfairly close the gap, taking advantage of the development of its massive high-speed rail network to unfairly seize foreign technology and know-how to support its local

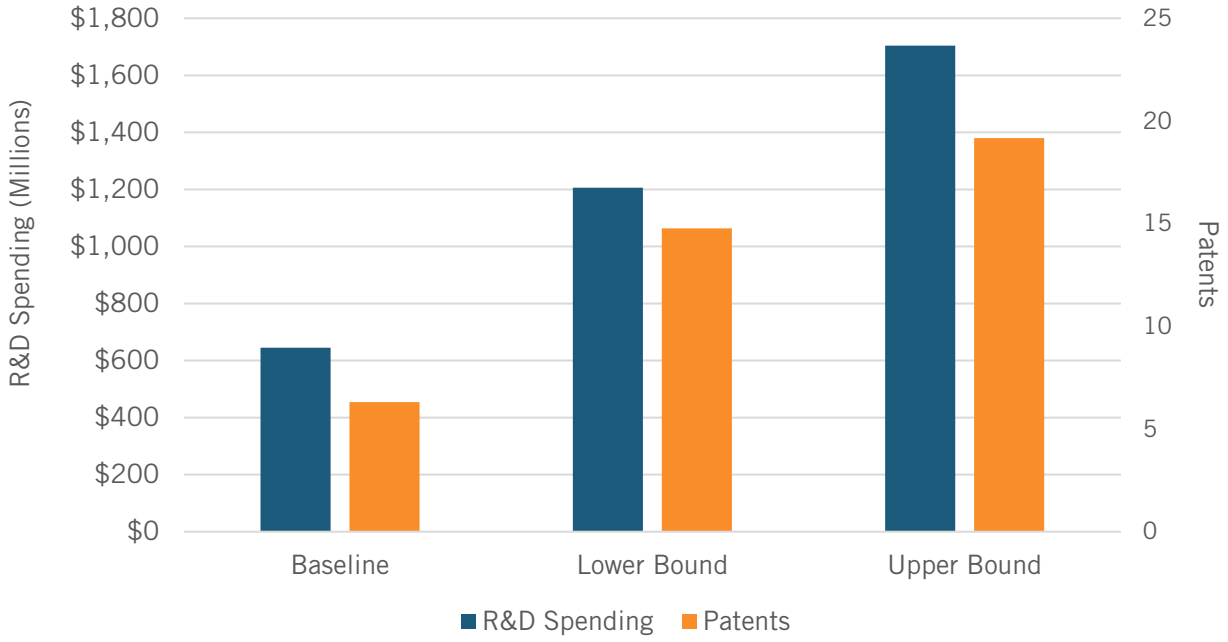
champion, CRRC, and other rail firms. This diverted huge amounts of revenue that would have otherwise gone to leading foreign firms if China's high-speed rail network had been based on comparative advantage and market-based industrial development. The impact of this will only grow as China supports CRRC's efforts to seize global market share. Chinese rail firms are increasingly competitive with foreign rail firms, but they remain less innovative. By continuing to take global market share from these more-innovative firms, China's rail industrial policy—rather than leading to better, cheaper high-speed rail systems—continues to detract from innovation in the high-speed rail sector.

China could just as easily have used its vast financial resources to import foreign rail products and rail systems, but it did not want to do that, even as it ran massive trade surpluses with the rest of world. It could have attracted foreign firms to set up their own local production and research facilities as part of a normal pattern of foreign trade, investment, and industrial development. Instead, it wanted local firms to control the rail sector. Over time, its mercantilist policies evolved as its firms became more competitive. It ratcheted up restrictions to help them move up the value chain and throughout the sector from freight to light rail and metro to large and fast passenger trains, before ultimately getting to the crown jewels: high-speed rail. China wanted to build up its own high-speed rail industry, for sale not only in China but around the world.

China did this through an array of unfair, mercantilist practices. In violation of WTO rules, China linked domestic rail contracts to forced foreign technology transfer. (High local content requirements are common in large rail projects, but forced technology transfers are not). They forced their two state-owned rail companies to merge to create their national champion, CRRC, which has about 95 percent of China's high-speed rail market, with Bombardier a distant second through its forced joint venture with CRRC.[43] Over time, local procurement rules increasingly penalized bids involving foreign firms, products, and technology, channeling more procurement contracts to local firms. China also provided huge subsidies and other financial support to domestic firms such as CRRC to not only expand in China, but to "go out" and seize global market share.

Outside of China, the major firms are Alstom (France), Bombardier (Canada, which Alstom recently acquired), Hitachi (Japan), Hyundai Rotem (South Korea), Kawasaki Heavy Industries (Japan), and Siemens (Germany). There are only relatively few firms because it takes large and long-term investments in R&D and CapEX to develop the necessarily technology and train systems. These firms lead consortiums of other rail firms and component suppliers as part of their bids for government rail contracts. This makes China's mercantilist approach to high-speed rail especially damaging, as there are few opportunities for these firms and their component suppliers to earn the sorts of revenue needed to further support innovation in a highly specialized set of technologies. More of the Chinese and global market for high-speed rail would have otherwise gone to these foreign firms—which did, and in many areas still do, lead in terms of advanced rail technology—if they were able to enter and compete on fair terms. ITIF estimated that in the absence of these unfair Chinese policies, greater market share would have provided foreign rail firms with the revenue to invest an additional $1.06 billion in R&D from 2015 to 2019, which would represent a 164 percent increase over their actual R&D spending. (See figure 2.) Given the revenue/patent ratio, these firms would have been able to develop an additional 13 patents (total) over this time, a 217 percent increase.

Figure 2: Total R&D spending and patents by foreign firms as per the baseline, fair trade, and market access (upper bound), and the "somewhat fairer" fair trade and market access (lower bound) scenarios (2015–2019)[44]



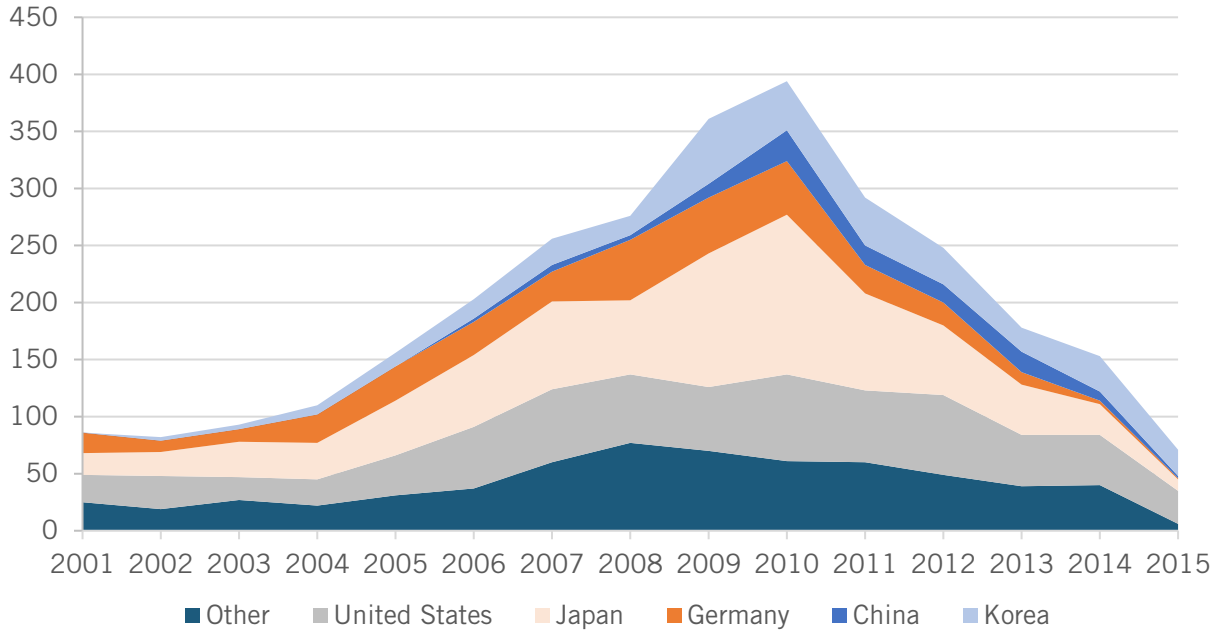
Solar Panels

China targeted solar panels as a key industry in the early 2000s. Between 2006 and 2013, China's global share of production of photovoltaic (PV) cells, the industry's core technology, surged from 14 percent to 60 percent. The global average price per watt of PV capacity dropped rapidly during these years, while the global market grew eighteenfold. Prices have continued to fall since then, and China remains the dominant producer.

Yet, for all their evident benefits, China's solar policies imposed costs as well: a change in the industry's pattern of innovation. Conventional indicators of product innovation, such as patenting and the ratio of R&D to sales, dropped precipitously in the wake of the Chinese surge. The decimation of PV manufacturing outside China drove many innovative firms out of the business entirely, in large part because they could not match the predatory prices offered by government-subsidized Chinese competitors. China's new PV giants have innovated in important ways, especially through process innovation that moved the industry's dominant technology rapidly down a steep experience curve. But the prospect of shifting to better, cheaper PV products with the potential for even greater emissions reductions over the long run has been deferred or even lost.

As figure 3 shows, patents in solar panels peaked in 2011, with Chinese firms receiving a very small share. This was also the year China's share of the global market nearly reached its peak of 60 percent, up from 14 percent in 2006. There was so much less revenue available to innovators (and fewer innovators, as Chinese-subsidized solar panels put so many foreign firms out of business) that patenting shrank dramatically.

Figure 3: Triadic patents for photovoltaic inventions by country, 2001–2015



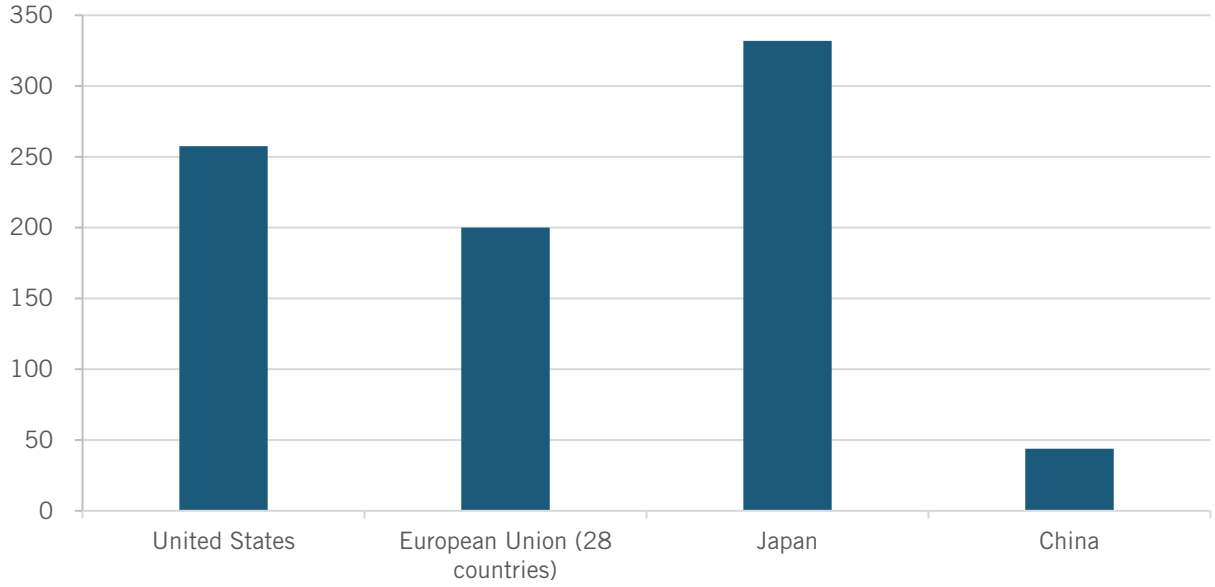
Biopharmaceuticals

The production of biopharmaceuticals—large-molecule biotech drugs and small-molecule chemical drugs—is one of the most innovation-intensive industries in the world. Unlike industries wherein China has already gained significant global market share, including high-speed rail, solar panels, and telecom equipment, China's global market share and competitiveness in biopharmaceuticals is still quite low, with the global leaders largely in the United States, and Japan and Europe following.

It is for this reason China has targeted the industry for global competitive advantage, as detailed in a number of government plans, including "Made in China 2025." China is taking a range of steps to propel itself to become a major global biopharma competitor, starting with developing a world-class generics industry. However, while some of these policy actions are fair and legitimate, many are not, and are innovation mercantilist in nature, seeking to unfairly benefit Chinse firms at the expense of more-innovative foreign firms. These include limiting market access of foreign drugs, weak patent protection so Chinese drug companies can get free access to foreign drug company IP, and subsidies to Chinese companies.

This is likely to matter to drug innovation going forward because, in 2016, China accounted for just 0.8 percent, 0.4 percent, and 1.5 percent of triadic patents (filed in Europe, Japan, and the United States) in biotechnology, medical technology, and pharmaceuticals, respectively, compared with the U.S. share of more than approximately 40 percent in each.[45] (See figure 4.)

Figure 4: Number of triadic biopharmaceutical patent applications by priority date per trillion USD of gross domestic product (GDP) in 2015[46]



Semiconductors

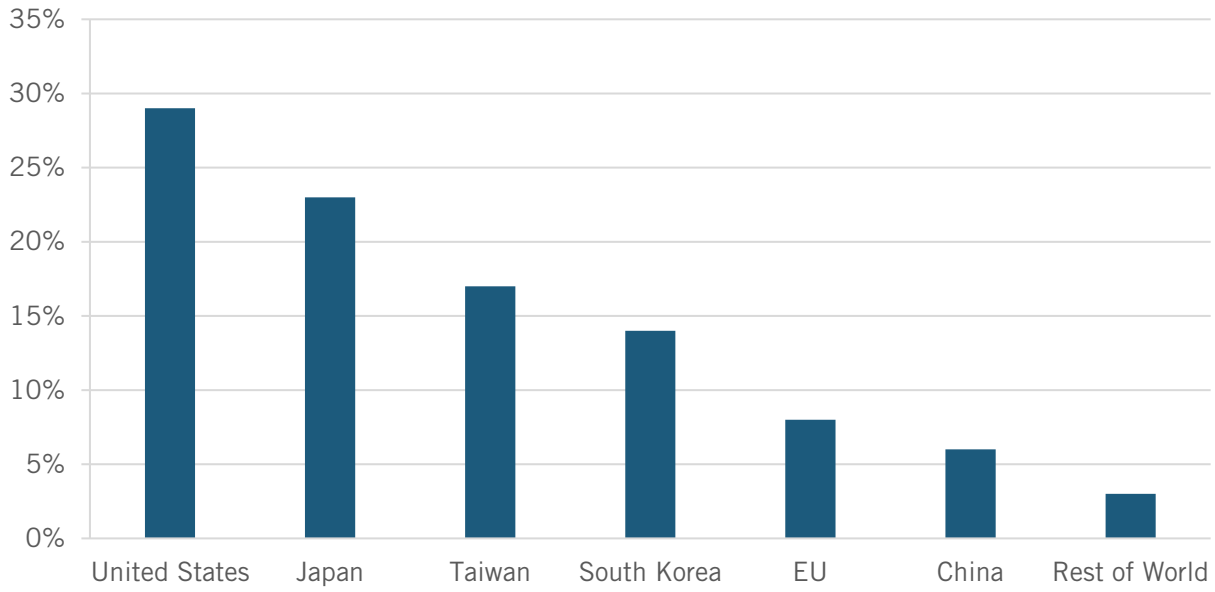
Semiconductors play a key enabling role in emerging technologies such as artificial intelligence (AI), high-performance computing (HPC), 5G, the Internet of Things, and autonomous systems, among others.[47] China's global market share and competitiveness in semiconductors, especially with regard to Chinese-headquartered firms, is still quite modest, with the global leaders largely based in Europe, Japan, South Korea, Taiwan, and the United States.

It is because of this that China has targeted the industry for global competitive advantage, as detailed in a number of government plans, including "Made in China 2025." China has taken a wide range of steps to propel itself into becoming a major global semiconductor competitor.

Even with this, Chinese semiconductor firms are about half as R&D-intensive as U.S. semiconductor firms and about 40 percent as EU firms; the more market share Chinese semiconductor firms capture over time will shift market power to less-innovative firms and thus decrease the level of R&D invested. And as shown in figure 5, Chinese semiconductor firms patent less than foreign firms.

There is a strong positive correlation (0.89) between semiconductor firm revenues in one year and R&D expenditures in the next.[48] Thus, Chinese semiconductor firms capturing sales and taking market share away from more-innovative enterprises empowers less-innovative firms and weakens the overall innovation ecosystem. Chinese semiconductor firms lag significantly behind the global leaders, usually by two generations of chip development, and Chinese firms patent less than the global leaders. As such, Chinese chip sales largely depend on unfair support from the Chinese government; and each sale reduces the pace of global semiconductor innovation by taking market share and revenue away from more-innovative non-Chinese firms. In fact, without Chinese innovation mercantilist policies in the semiconductor industry, there would be more than 5,000 additional U.S. patents in the industry annually than there are now.

Figure 5: Share of USPTO semiconductor patents granted by country/region, 2018[49]



OTHER INDUSTRIES

We can see the same negative on innovation in other industries.

Shipbuilding

Unfair Chinese policies to enhance its shipbuilding industry have hurt innovation in the industry. China identified shipbuilding as a "strategic industry" in 2006 as part of its 11th National Five-year Economic Plan 2006–2010. Shipbuilding was targeted as a strategic industry in need of "special oversight and support." The plan set the goal of China becoming the largest shipbuilding nation within a decade, which it did. As a result of its unfair policy interventions, China's global market share doubled from 25 percent to 50 percent. It increased the number of dry docks from around 37 in 2006 to over 130 in 2012. In contrast, Europe's dry docks fell from around 60 in 2004 to 25 in 2012.

A study by Harvard scholar Myrto Kalouptsidi found that Chinese government subsidies "decreased the cost of production in Chinese shipyards by 13–20% from 2006 and 2012.[50] This does not take into account the government-directed undervaluation of their currency, which provided their shipbuilders with another 25 to 35 percent price subsidy.[51] The study estimated that without the subsidies, China's market share would be cut to 50 percent, while Japan's share would increase by 70 percent.

This is one reason world prices for bulk carrier vessels fell by about 12 percent in nominal terms between 2006 and 2012, in part because of Chinese-induced global overcapacity. Without this, the study estimated, ship prices would experience moderate increases in prices, enabling companies to earn higher rates of return to invest in more R&D.

The study found that Chinese shipyards are less efficient than their Japanese and South Korean counterparts. As such, the Chinese subsidies and other distortions "led to a large increase in the industry average cost of production (net of subsidies) by shifting production away from low-cost

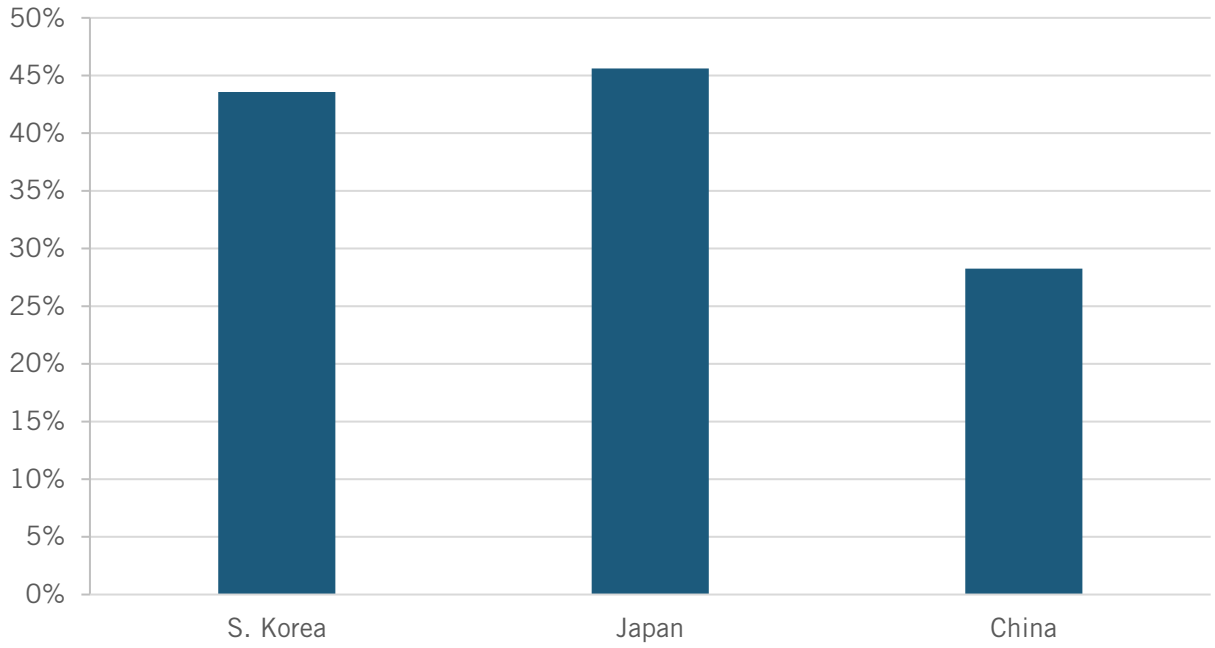
Japanese shipyards towards high-cost Chinese shipyards."[52] In other words, while Chinese production was low-price, it was high cost.

Also, Chinese producers were anything but innovative. Korean and Japanese shipbuilders had a 14- and 12-times larger share, respectively, of global patents than Chinese shipbuilders from 2015 to 2018.[53] China was awarded just 24 patents from 2000 to 2018, compared with 320 for Japan and 225 for Korea. Moreover, from 2011 to 2018, global patenting in the industry fell by 47 percent. Out of 28 countries other than China, 26 saw a fall in shipbuilding patenting during this period. One reason was that, in many cases, non-Chinese shipbuilding R&D fell as Chinese competition cut into margins.

Motion Pictures

We see the same dynamics in the movie industry, on which China imposes a number of protectionist policies, including limiting the number of foreign movies allowed to be shown in China annually to just 34. And unlike with virtually every other nation, Chinese regulations severely limit the share of box office revenues given to foreign film production companies. For example, in 2019, only 28 percent of movie revenues in China went to U.S. firms, while the shares of movie revenues in Japan and South Korea to U.S. movie studios were 45 percent and 44 percent, respectively.[54]

Figure 6: Film revenue to U.S. movie studios as share of total box office, 2019[55]



While quantitative measures of innovation are not available, the U.S. movie industry is widely seen as the most technologically sophisticated in the world. In contrast, a study of China's movie industry noted that "the quality of the films produced in China is, at best, variable. One of the reasons for the inconsistent quality of Chinese films is a shortage of skilled labour. Industrial personnel typically lack adequate formal training for specialized roles, especially live broadcasting."[56] This is reflected by the fact that the top 10 grossing movies of 2019 were all American made.[57]

Chinese movies are not yet a significant threat to U.S. film revenue outside the United States, but protectionist Chinese policies do limit global U.S. film sales and, as such, limit the ability of U.S. film studios to invest as much or more to produce more movies.

Aerospace

China has pursued the same innovation mercantilist policy in aviation. Designing and building jet airplanes, especially larger, multi-aisle planes, is incredibly expensive and risky. Given this, it is not surprising there are just two major competitors: Boeing and Airbus. But this has not deterred the Chinese government from attempting to artificially create a third competitor. Commercial Aircraft Corporation of China, Ltd. (COMAC), the state-owned Chinese commercial aircraft company, benefits from a wide array of mercantilist policies, including massive subsidies, discriminatory procurement, and forced technology transfer in exchange for market access.

COMAC's C919 single-aisle jet is on track to be certified as airworthy this year by Chinese aviation authorities.[58] And over the next ten years. it is projected to sell 500 jets, almost all in China to state-owned airline firms that are under pressure to buy from COMAC.[59] The massive subsidies to COMAC also make it possible for them to sell the C919 at significantly lower prices than either the Airbus or Boeing alternative. The result will be reduced revenues for Boeing and Airbus to invest in next-generation aviation innovation.

ARGUMENTS AGAINST CHINA'S INNOVATION HARM

While the logic and evidence for China's negative impact on global innovation is strong, some may raise objections. This report addresses five such objections.

The first is the "we're all sinners" argument." In other words, while China may engage in unfair practices such as subsidies and forced technology transfer, most other countries do as well. Therefore, China's negative effect is no worse than other nations'. Some argue that the United States, especially state governments, also provide subsidies, implying that China and the United States are similar. But this ignores two things. Subsidies are not the principal policy tool the Chinese use to gain unfair advantage—forced tech transfer, closing domestic markets, IP theft, and others play a large role, none of which the United States engages in. Second, just because two nations engage in the same behavior does not make them equivalent any more than a 50 percent tariff is equivalent to a 5 percent tariff. In fact, U.S. state government subsidies are quite limited. For example, the *Wall Street Journal* reported that Huawei received around $75 billion in Chinese government subsidies, while Cisco received around $44 million, almost all from state governments.[60]

Second, some may argue that patenting being lower in industries in which the Chinese overinvest could be a healthy consequence of the maturation of markets wherein products are now manufactured at scale and diffused through the world. But this dynamic doesn't apply to the five industries ITIF reviewed. Telecom equipment companies are working on 6G technology. High-speed rail companies are working on technologies such as maglev and hyperloops.[61] Solar panel companies are working on perovskite solar cells, thin films, and solar paint.[62] The biopharmaceutical industry is in the midst of technological revolution based on genomics and nanomaterials. And semiconductor companies are working on ensuring Moore's Law (the observation that the number of transistors in a dense integrated circuit doubles about every two years) does not come to an end.

Third is the issue of whether there is a difference in the global innovation effect between constructively innovative Chinese companies and those that are less innovative. In other words, while Huawei and CCRC were technology laggards whose government-supported growth hurt foreign innovation leaders, there may be other Chinese sectors and companies that are in fact leaders in their own right and whose advancements also advance global innovation. Here, one might point to the BATs (Baidu, Alibaba, and Tencent) that appear to be innovating significantly in a number of areas, including AI and payments. (Interestingly, while these firms have benefited significantly from the Chinese government limiting foreign competitors, they don't appear to have received significant direct government support.) Another area is China's efforts to develop a national digital currency, which would be a net addition to global innovation.[63] So when China intervenes unfairly in particular sectors or technologies, its effect on global innovation is likely to be negative. But when it provides an enabling environment for innovation, it can contribute to innovation both in China and globally.

Fourth, while these policies may be problematic, it's not clear exactly where the harm is. Intel is still producing chips. The U.S. biopharma industry is still innovating. And Ericsson and Nokia are producing 5G equipment.[64] But this is a bit like saying that "unless the patient is in the hospital, there is no harm." And as noted, many of these companies may still exist and be profitable, but because of unfair Chinese policies, they are neither as big nor as innovative as they would be otherwise, with less to invest in R&D. Moreover, many "patients" were in the hospital and still "died." Hundreds of solar panel companies in developed nations went out business because of unfair Chinese policies. Nortel, a global leader in telecom equipment, went out of business because of Huawei competition and Chinese IP theft.[65]

Finally, some argue that China's spending creates big markets that spur innovation. Case in point is China's unprecedented investments in high-speed rail, smart cities, renewable energy, and 5G networks. Such demand-pull policies are critical to innovation.[66] The problem comes when Chinese governments limit the bidders for these projects to less-innovative Chinese firms, thus constraining innovation relative to if they allowed competitive, merit-based bidding wherein many more contracts would go to foreign innovation leaders.

POLICIES TO MAXIMIZE GLOBAL INNOVATION

If China were to reduce its unfair innovation mercantilist policies, the pace of global innovation would increase. But in a classic win-lose dynamic, China shows no inclination to do so. This means other nations committed to accelerating the pace of global innovation need to act. There are five main things these nations should do:

1. WTO should be encouraged to focus more on innovation and innovation effects from trade distortions. WTO largely focuses on static issues in trade (e.g., the increase in prices from trade barriers), not on dynamic or innovation issues. This needs to change.
2. As ITIF has articulated, non-mercantilist nations, including Commonwealth nations, the EU, Japan, and the United States, should work more closely to pressure China to roll back at least the most egregious of its mercantilist policies.[67]
3. Allied nations should limit market access for Chinese innovation-based goods and services that are supported by Chinese government innovation mercantilist policies.

4. Allied nations should establish formal agreements to cooperate more on technology policy, including establishing reciprocity in their technology policy programs to allow each other's companies to participate in each other's national technology programs.
5. Allied nations should establish stronger trade agreements to allow for the free flow of innovation-based goods, services, and data between those nations. This should include an agreement to eliminate tariffs on imports from each other for all innovation-based goods.

CONCLUSION

The challenge of Chinese innovation mercantilism is not just to the U.S. economy and national security. It is to the entire globe, and innovation across a wide array of sectors. It is common for pundits to say that it is good that China is innovating: China may invent the cure to cancer. That statement would only be true if China were innovating in a way that was consistent with Organization for Economic Cooperation and Development (OECD) guidelines on appropriate innovation policy (e.g., supporting basic, early-stage research; funding research universities and STEM education; allowing open markets; and protecting IP). But, again using cancer as an example, because China has chosen an innovation mercantilist model, China's gains in treating cancer would be offset by losses in other nations with more-innovative biopharma firms.

If a robust rate of technological innovation in the world is what we want—and we all should if we value human life, the planet, and increasing living standards and quality of life—then the entire world has a stake in encouraging China to roll back its innovation mercantilism and replace it with effective and non-distorting innovation policy, like most OECD nations engage in.

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The Information Technology and Innovation Foundation (ITIF) is an independent, nonprofit, nonpartisan research and educational institute focusing on the intersection of technological innovation and public policy. Recognized by its peers in the think tank community as the global center of excellence for science and technology policy, ITIF's mission is to formulate and promote policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress.

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