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Testimony before the U.S. - China Economic and Security Review Commission
June 8, 2018

Hearing on "U.S. Tools to Address Chinese Market Distortions"

Chairman Cleveland, hearing co-chairs Commissioners Hubbard and Stivers, commission members, staff, and other distinguished guests, good morning, and thank you for the invitation to speak with you today.

I am going to focus my testimony on two main areas: first on Chinese policies and practices, and then on some positive steps we as a nation can take to respond.

Much has been said before this commission about ways to respond to Chinese policies, or how to get China to stop doing things that are basically unfair, like stealing intellectual property (IP). In order to fully understand these issues and formulate appropriate policy responses, I think it is important to dissect the issue into several components: (1) reverse engineering and copying, (2) false representation upon sale, (3) jurisdiction, and (4) misappropriation. With that background we can understand the core issue: industrial knowledge and know-how flowing to what the National Security Strategy calls a strategic competitor.

Reverse engineering has its roots in the analysis of hardware, where deciphering designs by disassembly and analysis of finished products is commonplace. In the U.S., the legal definition of reverse engineering comes from a case that was heard by the U.S. Supreme Court: *Kewanee Oil Co. v. Bicron Corp., 416 U.S. 470 (1974).* Former employees of the Harshaw Chemical Co., a unit of Kewanee Oil, later formed or joined Bicron Corp. and were accused by Harshaw of misappropriating trade secrets used to grow large sodium iodide crystals for use as ionizing radiation detectors. The court ruled that trade secret law "does not offer protection against discovery by fair and honest means, such as by independent invention, accidental disclosure, or by so-called reverse engineering, that is by starting with the known product and working backward to divine the process which aided in its development or manufacture." The reverse engineering of manufactured products is a way to acquire know-how through disassembly, measurement, and analysis. Reverse engineering is very common and it is an accepted practice. I recently spoke with an executive at a U.S. automaker who admitted that they reverse engineered Tesla's vehicles as well as those of other manufacturers. In the Chinese context, this

is what is most important to companies located there – the ability to learn quickly how things work and to then make their own versions. It might be laziness or lack of time that induces direct copying without modification. What is not permissible is direct copying for *sale* of patented or copyrighted products. For example, making a copy of a Cisco router is permissible if you don't copy the copyrighted software or patented parts. The software includes the firmware, which is a key component. But re-engineering the firmware and copying non-patented components is permissible, as long as you remember that hardware patents could prevent you from selling your copy. An instructive example of some of these subtleties can be found in the IBM PC clone market, in which IBM thought they were protecting the design and function of their PC with a chip that was called the Basic Input Output System (BIOS), software instructions stored into memory (known as firmware) that they copyrighted. Engineers at Phoenix Technologies produced a "clean room" copy with a circuit that produced identical outputs given any given set of inputs, creating the Phoenix BIOS. That launched the IBM PC clone market, because everything else could be assembled from commercially available components.

Next, the subject of false representation upon sale. In *Bonito Boats, Inc. v. Thunder Craft Boats, Inc.*, the Supreme Court argued that "the competitive reality of reverse engineering may act as a spur to the inventor, creating an incentive to develop inventions that meet the rigorous requirements of patentability."[1] The Court ruled that it was not illegal for Thunder Craft to use a Bonito boat hull as a "plug" to make a mold for its own boat hulls. Thus direct copying of a design that was not patented was permissible.[2] What would not have been permissible would have been Thunder Craft selling boats under the Bonito name, citing a Supreme Court case from 1917:[3] "The plaintiff has the right not to lose his customers through false representations that those are his wares which in fact are not, but he may not monopolize any design or pattern, however trifling. The defendant, on the other hand, may copy plaintiff's goods slavishly down to the minutest detail: but he may not represent himself as the plaintiff in their sale."

False representation, as much as the copying of designs, has been the big issue for global brands in China and emerging markets. The flood of fake Rolex labeled watches, sport utility vehicles dubbed the "Hilux Safe" that are copies of Toyota Motor's popular off-road Hilux Surf, fake Gucci handbags attract a lot of attention and the ire of the original brand holders. Selling knock-offs with a false brand representation is not allowed in countries with strong property rights regimes, but it is quite a different activity than simply making copies or "close imitations." American companies like Nike and Disney have this problem in spades in China, though my understanding is that Disney has made considerable progress through innovative actions it has taken. Lesser known but very serious are problems that companies like Cisco have with counterfeit products coming out of China and being sold on global markets including within the U.S.

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[1] *Bonito Boats, Inc. v. Thunder Craft Boats, Inc., 489 U.S. 141 (1989).*

[2] The U.S. Congress subsequently enacted the Vessel Hull Design Protection Act as part of the Digital Millennium Copyright Act, providing copyright protection to boat hull designs.

[3] *Crescent Tool Co. v. Kilbourn & Bishop Co., 247 F. 209, 301 (CA2 1917).*

Was the Chery QQ, a city car produced by Chery Automotive an illegal copy of the Daewoo Matiz, as claimed by General Motors, the owner of Daewoo Motors? It was branded Chery, though a Daewoo spokesperson claimed that "If you didn't have the name tags on the car, you couldn't tell them apart. It's such a knockoff that you can pull a door off of the Chevy Spark and it fits on the QQ - and it fits so well that the seals on the door hold."[4] It depends on whether any part of the vehicle infringed on currently valid patents held by Daewoo in China, or where Chery tried to sell the vehicle. An official from China's State Intellectual Property Office stated that the infringement would not be "set up" unless GM could provide information on how Chery gained information about the Spark's appearance by illegal means.[5] Thus the burden of proof of infringement fell to Daewoo, assuming it even had patents on file in China. I recently spoke to a manager at a Japanese car company who explained that they had experienced the same copying of a car body and entire chassis. The doors in their case were interchangeable as well.

In the U.S. or regions where there is a strong property rights regime, once an unpatented design or a design whose patent has expired is "disclosed" through public sale, the law states that it is in the public domain and copies may be sold by anyone who chooses to do so. This is one of the pillars of patent law. Summarizing from *Kewanee Oil Co. v. Bicron Corp*., the Supreme Court stated, "The stated objective of the Constitution in granting the power to Congress to legislate in the area of intellectual property is to "promote the Progress of Science and useful Arts." [6] The patent laws promote this progress by offering a right of exclusion for a limited period as an incentive to inventors to risk the often enormous costs in terms of time, research, and development. The productive effort thereby fostered will have a positive effect on society through the introduction of new products and processes of manufacture into the economy, and the emanations by way of increased employment and better lives for our citizens. In return for the right of exclusion — this "reward for inventions," *Universal Oil Co. v. Globe Co., 322 U. S. 471, 484 (1944)* — the patent laws impose upon the inventor a requirement of disclosure.

Next, the all-important topic of jurisdiction. Patents are granted by governments, and convey the right to exclude others from making, using, selling, offering to sell, or importing a protected invention within the territory of jurisdiction. Patent grants gave inventors an exclusive period of benefit in exchange for disclosure of the invention. It's important to understand that patents filed only in the U.S. only prevent the sale of infringing products imported into or made by one who copies in the U.S. If you want to protect a product from copying in China, you have to file there as well. The U.S. is the world's most important market, and our strong patent enforcement environment, a mature legal system for handling patent disputes, and the economics of enforcement make the U.S. unique. This is why you can actually find Chinese companies like Huawei and ZTE fighting each other in the Northern District of California. But

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[4] Ralph Hanson, "Chinese Chery QQ – a carbon copy of the Daewoo Matiz," Motorauthority.com, http://www.motorauthority.com/blog/1029627_chinese-chery-qq--a-carbon-copy-of-the-daewoo-matiz

[5] "Chery QQ: No GM Patent Infringement," China.org.cn, http://www.china.org.cn/english/BAT/106449.htm

[6] *Kewanee Oil Co. v. Bicron Corp., 416 U.S. 470 (1974).*

it also means that if you operate in China, you have to understand China's patent laws and systems and work within them.

These were major reasons for bringing China into the World Trade Organization (WTO). The WTO's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) introduced intellectual property rules into the multilateral trading system. The TRIPS agreement covers five broad areas:[7]

- How general provisions and basic principles of the multilateral trading system apply to international intellectual property
- What the minimum standards of protection are for intellectual property rights that members should provide
- Which procedures members should provide for the enforcement of those rights in their own territories
- How to settle disputes on intellectual property between members of the WTO
- Special transitional arrangements for the implementation of TRIPS provisions.

By joining the WTO, China was supposed to make sweeping changes to hundreds of its laws, regulations, and measures affecting trade and investment. These are at the core of our disputes today – China's poor compliance is reported to Congress annually.

The 2016 U.S. Trade Representative (USTR) to Congress on China's WTO compliance pointed out that "Chinese government officials, acting without fear of legal challenge, at times require foreign enterprises to transfer technology as a condition for securing investments approvals, even though Chinese law does not – and cannot under China's WTO commitments – require technology transfer." In practice, how does this happen? Perhaps the best-known example was requiring foreign automakers to have a joint venture partner to manufacture and sell into the Chinese market.

The report continued, "Similarly, in the trade remedies context, China's regulatory authorities at times seem to pursue antidumping (AD) and countervailing duty (CVD) investigations and impose duties for the purpose of striking back at trading partners that have legitimately exercised their rights under WTO trade remedy rules. As three WTO cases won by the United States confirm, China's regulatory authorities appear to pursue these investigations even when necessary legal and factual support for the duties is absent. In addition, U.S. industry and industries from other WTO Members have asserted that China's competition policy enforcement authorities not only are targeting foreign companies, but also at times use *Anti-monopoly Law* investigations as a tool to protect and promote domestic national champions and domestic industries." Qualcomm has suffered at the hands of this policy, paying $975 million as part of a settlement. China did not like its champions like Huawei or Xiaomi Technology having to pay high royalties to Qualcomm for use of its patents. This was basically an

[7] See "Intellectual property: protection and enforcement," https://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm7_e.htm.

argument over patent rates and how they were calculated. I could say much more about this space, but the USTR has done a thorough job of documenting them.

Let me move on to the subject of misappropriation. This is really the central strategic issue facing us – the misappropriation of core industrial and scientific know-how. Much has been said about cyber-espionage and theft of trade secrets. I am not an expert on that, so I will not make any statements on this. But the real issue is how do Chinese firms acquire the explicit knowledge, as well as the all-important tacit knowledge to become world-class competition for American firms and firms from other advanced economies.

There are legitimate mechanisms. Know-how can walk out the door in the heads of employees. I once met a gentleman on an airplane bound for Shanghai. He was a retired aerospace engineer from McDonnell-Douglas, and was on his way to central China to teach a company how to fabricate titanium structures. I asked him a few more questions, and learned that he had been hired as a consultant, and this was all perfectly legal. I also interviewed a senior manager at a major Chinese battery maker a few years ago who had once worked at a well-known American firm that was trying to break into the Chinese market. Because the American company was trying to avoid import duties, they needed to increase their local content, so he worked with the battery firm to improve its quality and fix its production processes. He helped them significantly, teaching them about quality and lean production. And when the American firm eventually got taken over, he left it to join the battery firm. That battery firm today is a global market leader.

The more problematic situations are when companies are required to form joint ventures, as in automobiles for example. Joint ventures are an important way for the junior partner to learn how to do things, and the senior partner becomes the tutor. It is in the economic interest of the Western partner to make the venture successful, and it will bring in its production processes and teach its own and its partner's employees processes and methods. Over the short term both sides win, in what amounts to a trade of market access for know-how. The problem with China's approach is that China requires joint ventures in fields that it thinks are strategically important, and essentially trades market access for an accelerated path for its companies, many of whom are state-owned enterprises (SOEs), to become world-class competitors.

Then of course there is strategy of acquiring firms for their knowledge and capabilities. We have long believed in letting the market do its work, and that mergers and acquisitions were fine as long as consumers benefit and they don't create concentrations of market power. Companies from almost every country do this in the normal course of business – Tesla needed to automate its Model 3 production line, so it bought Grohmann Engineering of Germany, General Motors needed to fast-forward efforts in self driving vehicles so to it bought Cruise Automation. The problem we have with Chinese companies buying U.S. technology companies is that China plays by a different set of rules – rules on ownership, on what can be acquired, and how things are financed, often by State capital in non-market ways.

If I wanted to sum up the discussion up to this point, I think our sense of unfairness comes from China operating under global norms and rules when it is to its advantage, and its own rules when those are advantageous. And since their system is a modified market-based system "with Chinese characteristics," it conveys advantage to Chinese firms.

I think the best thing we can do is gain consensus with a select set of allies who recognize that they have as much to lose from this misbehavior as we do. I was in Germany last week, and there is heightened sensitivity to the way the Chinese are buying up technology assets, copying things, and foreshadowing a world where German manufacturing sources get replaced by Chinese ones. If we work together with key industrial countries specifically Germany, Japan, the United Kingdom, France, and South Korea on standards of acceptable behavior, China will have no choice but to follow. If we try to do by it ourselves, we will be played against the others, or worse, a coalition of the others.

Two more things that we should think about. We recently cut off ZTE's ability to source American designed electronic components because of their violation of a sanctions settlement. This has caused an existential crisis at the company, which has been widely noted across China. I was in China four weeks ago, and I can't tell you how many people asked me about it. As we increase the pressure on China and Chinese companies, it will lend further urgency to the country's drive to become self-reliant on technologies that they presently import. This of course is the thrust of their Made in China 2025 initiative. We therefore should think very strategically vis-a-vis our actions in this regard.

There are many avenues for misbehavior, and cutting off one will push firms, regional governments, and the national government into other channels. For example, when the International Trade Commission (ITC) imposed a duty on Chinese made solar panels in 2012, many manufacturers moved assembly to places like Malaysia using materials and key components sourced from China.

My second point is on Chinese government subsidies to specific industries. In my opinion, subsidies tend to reduce innovation. They have a tendency to cause companies to focus on trying to beat everyone else as the low-cost producer. This encourages them to recklessly add capacity in the pursuit of scale, and find every place they can to squeeze cost or otherwise tip the scales. This is one of the things that is commonplace in China today. Once somebody comes up with a good idea, everybody piles on and does the same thing. Regional and municipal governments turn on the subsidies, everybody adds too much capacity, and the business becomes a race to the bottom. In my opinion, Chinese state and local government subsidies are the most pernicious issues we face.

If we step back and look at the big picture, we can try to slow down the copying and bad behavior. But at the same time we should spend much more energy trying to open up the gap

in areas where we lead and exploit our strengths as the most innovative *and* the most powerful economy on the planet. In other words, not just slow them down, but run faster ourselves. Are we really leveraging both of these attributes to maximum effect? Maybe we have gotten old and are a little out of shape, but when we see other countries nipping at our tail, we should whip ourselves into shape and get moving.

We need to up our game in things we do well where we can leverage our strengths. First, we can strategically target bringing certain manufacturing capabilities and activities back to the U.S. I lived through a lot of the history of semiconductors and electronics moving offshore in the first place. When we first started ramping up the volume of integrated circuit manufacturing in this country, we started sending the processed wafers to Asia for testing and packaging. A semiconductor wafer is eminently tradable – it has a high value density and it doesn't cost a lot to ship one half way around the world as a percentage of its value. We sent wafers to Malaysia or Singapore, where workers looking through microscopes wire-bonded gold wires to the chip pads, put them in packages, and then sent them back. The process was very labor intensive, so by employing labor arbitrage, we could save a lot of money. Same thing for electronic circuit boards, and assembly. At first the work went to Japan and Singapore, then Taiwan and Korea, but ultimately a lot of it ended up in China. And China did a super job in the 2000s getting manufacturers to localize their supply chains by offering reduced duty and access to the Chinese domestic market.

These days chip packaging is really high tech. The connections are dense and complex, so the whole process is completely automated. It still sits in Asia, because that's how the supply chains are organized. And before tax reform, there were advantages to doing that value-add offshore. It was called accumulating profit in low-tax locations. But that doesn't need to be the case today.

Let's look at hyper-scale data centers being built by our friends at Amazon Web Services, Google, Microsoft, Facebook, the National Security Agency, and others. I think Intel builds the Xeon chips in Hillsboro, Oregon (and/or maybe Phoenix), then ships them to Asia for testing and packaging, then they go into a distribution center where they feed server board manufacturing lines in China, and then they come back to the U.S. and go into those datacenters up the Columbia River from Portland and other places of course. Those Asian steps are highly automated, though they still create a fair number of jobs.

What if we had an import processing zone, where we could invite some of those Taiwanese chip packaging firms, or some of the Taiwanese server board firms, to set up next door to the Intel fab? With our new tax law and the ability to expense the capital equipment immediately, we could start restoring some capability to the U.S. There is also less tax justification for invoicing from offshore. And frankly, the logistic simplicity and the amount of inventory you would take out of the supply chain might financially justify the whole thing. I heard Amazon alone is buying 10% of Intel's Xeon chips this year. Add in Google, Facebook, Microsoft, and Apple. Maybe a little more from each of Oracle, IBM, HP, Dell, and you have quite a bit of

volume. Harness our domestic demand and use it to rebuild part of the electronics supply chain and along with it the industrial capabilities. I would expect those NSA datacenters would love the local sourcing model. And it would play into the technology trend of 3D packaging as a way to address the continuation of Moore's Law. It would also strengthen our ability to sustain the most advanced semiconductor fabs in the United States, which I think is absolutely critical.

This is not rocket science. It's just looking carefully at how things have evolved, and then checking the underlying assumptions. Maybe we should check into why the old tax law drove so much medical device manufacturing offshore, and see if those reasons are still valid. We should look at our assets, play offense, play aggressive, rethink our assumptions.

In that light, we should talk up the benefits of localizing supply chains. For their Georgetown, Kentucky assembly site, Toyota pulls on 350 suppliers locations in the U.S. and 100 in the state of Kentucky alone. Vehicles coming from this factory have among the highest domestic content on any vehicles produced in the U.S. Toyota has found it to be a strategic advantage to localize their supply chains, just as Chinese local governments encouraged manufacturers to do in the 2000s. That's not to say that U.S. firms don't think the same way. I just think many have adopted more of a global sourcing mindset – find me the lowest cost with acceptable quality anywhere in the world. So rather than help my local machine shop upgrade, I'll move the work to Poland or China or India. Toyota obviously thinks local sourcing is an advantage. Having recently toured their operations I can assure you they are not stupid. They work with their suppliers to upgrade their capabilities. They have taught the world a lot about manufacturing, and we should pay attention to how they run their supply chain. Maybe we need help to local governments and regions to help them upgrade suppliers and focus on localization. And maybe we should point out to companies that this is part of being a good citizen in the community, which is also an important constituency. Again, with the changes to the tax law, there has never been a better opportunity to do this. The challenge will be finding enough workers.

I think the best thing we can as a country do is run faster. This was what the PCAST report, "Ensuring Long-Term Leadership in Semiconductors" said, and I think that applies not only in semiconductors, but in almost every technology-driven field. That plays to our strengths, because we continue to be the world leader in basic scientific research, and in coming up with transformative innovations.

And as I said, we need to act strategically. The May 2018 Economics and Trade Bulletin published by the Commission highlighted areas where the U.S. still has a trade surplus with China. Aerospace is one of those areas. Western countries, the U.S. in particular, are very good at complex systems. If you look at a Boeing's 787 or their new 777-X, or an F35 for that matter, those are very complex systems. It took Airbus, with extensive European subsidies, decades to learn how to do that well, and we can see even very competent manufacturers like Mitsubishi struggling today with their MRJ family. I think the way Boeing (and now Airbus) are reacting

to the threat of the Chinese competition, Comac with its C919 and Irkut with its MC-21, is to incessantly improve their product, drive their manufacturing efficiency, and try to always be a generation or more ahead. The nice thing about this approach is that even Chinese airlines, though they are pressured to buy the Comac product, need to buy Western so that they themselves can stay competitive.

Another reason I advocate this line of thinking is that capabilities come from practice. And Chinese companies (and those from other Asian nations before them) got very good at copying. I did a study on the history of the Chinese motorcycle industry ten years ago. They got started copying the parts of Honda, Yamaha, and Suzuki motorcycles from Japan. So hundreds of firms sprung up as assemblers. And they got very good at doing incremental improvements. But I remember saying at the time, if I were one of the Japanese makers, I would go tell my engineers to go improve the thermal efficiency of my engines. That's something people who grew up on copying will take a little longer to figure out.

One of the big U.S. commercial aero engine manufacturers has taken a very strategic approach in protecting its lead. They have been systematically increasing the compression ratio of their high-pressure sections and along with it the thermal efficiency of their engines. This encompasses design, a great deal of work with new materials, and a manufacturing strategy that spreads critical components across a network of highly specialized plants spread across the southern and eastern states. Nobody has all the pieces of the gun, so to speak. But the company knows what they have to protect, and they guard those trade secrets jealously.

Continuing on this example, there is also a great story of how our government can help. Back in the 1970s, NASA supported foundational research with its Aircraft Energy Efficiency program, what one author called the Apollo Program for aeronautics. The program came out of a hearing before the Senate Aeronautical and Space Sciences Committee in the wake of the 1973 Arab Oil Embargo. The hearing painted a dire picture of "immediate crisis condition," "long-range trouble," and "serious danger." NASA contracted with both Pratt & Whitney and GE to do early stage research on advanced propulsion systems for subsonic aircraft, with involvement from Boeing, Lockheed, and McDonnell-Douglas. This became a learning platform that was of immense value to the companies and U.S. industry more broadly. The Experimental Clean Combustor program sponsored early development of the Dual Annular Combustor at GE, which went into the CFM-56 engine, the most commercially successful turbofan engines in history. The CFM LEAP, which is the next generation of that engine, is even used on the C919. The Advanced Subsonic Technology (AST) and Ultra Efficient Engine Technology (UEET) Programs similarly helped advance the basic science and helped secure long term global leadership for the U.S. in the large turbofan category. It was pre-competitive research at its best. In that regard, the Aerospace Innovation Act introduced on May 24 by Senate Aerospace Caucus co-chairs Warner and Moran holds promise for continuing that tradition.

Computers, semiconductors, lasers, optical communications, cloud computing, smartphones, supercomputers, GPS – they all started with us. I would argue that the historic lead the U.S. had in communications technology came out of defense spending as well. We all know that the

Internet came from DARPA's work in packet switching, but recall also that Qualcomm's strength came out of a big bet that it made on code-division multiple access (CDMA), based on DOD's work on spread spectrum technologies.

We should also try to strengthen our leadership in biotechnology. The massive and well-coordinated funding for the Human Genome program and the interdisciplinary effort mounted at places like MIT and Harvard among others secured this country's position in the field. And it was more than just the basic gene sequencing work, but also the federal funding before for places like MIT's Chemical Engineering department that taught us how to manufacture biopharmaceuticals. These are things that we do better than any other nation on earth. We should do more of it, and work harder to expand our lead.

I am arguing for more of this kind of work, and more importantly, stable funding for basic research. Federal funding for basic research has been flat in recent years, with NSF and NIH trending down until this year. Stable funding is vital in our military procurement programs as well. Long term budget uncertainty and years of sequestration has been highly counterproductive for defense manufacturers. Imagine if you are trying to run a long-term R&D program in the application of carbon fiber composites or some other advanced material to aerospace applications and you don't know how many people you can afford to have on your payroll from week to week. Would you want to work at a place like that?

Our government helps by being an early adopter of new technologies. We did this with semiconductors and integrated circuits, jet engines, GPS, design automation tools, composite materials. Even antibiotics and computers if you go back to World War II. We should look upon the pressing need to re-engineer our national electrical grid for security and to move to the new world of distributed generation as another such opportunity. We should pay attention to crop science, agrochemicals, and the application of biotechnology. The Chinese acquisition of Syngenta signals the recognition of the importance of the technology.

Lastly, I urge the President to re-charter the PCAST – the President's Council of Advisors on Science and Technology. We need a channel for more ideas and advice on how to secure our lead in science and technology, which ultimately drives our economic leadership. Going back to the PCAST report on semiconductors, that won bipartisan support. It had a lot of good ideas on what we can and must do.

At the Harvard Business School, we teach students that strategy is an integrated set of choices that collectively position the firm in its industry so as to create sustainable advantage relative to competition and deliver superior financial returns. What should our strategy as a nation be? How should we position ourselves for a sustainable global economic leadership in the face of freer movement of capital, goods, and services? We can slow down our strategic competitors, but at the end of the day, we win by running faster and opening up the gap.

Thank you very much for the opportunity to speak before you today.