Factors influencing the advancement of China's military technology
Testimony before the U.S.-China Economic and Security Review Commission
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In 1983, four senior Chinese scientists wrote to Deng Xiaoping, saying that China was far behind the West in technology and if it did not take steps to catch up, China could find itself relegated permanently to a second class status. Deng's swift response led to the 863 program, the first of many government programs that invested to build Chinese science and technology base for both economic and military goals. Since the end of the Mao era, a central tenet of Chinese national security and economic policy has been to catch up to and perhaps surpass the West.

China's economic model has, until recently, been the most successful in the world in terms of sustained development. The next decade will see world class Chinese commercial products enter the global market. These will be high quality products offered at lower prices and sometimes supported by heavy government subsidies and by non-tariff barriers to trade. The elements of the Chinese economic model are:

- Heavy government investment in human capital and in infrastructure;
- Subsidies and non-tariff barriers first implemented to attract foreign investment and now used to build national champions
- Weak regulatory barriers to business activity (in part because of rampant corruption) and a flexible labor market;
- Illicit acquisition of foreign technology.

Chinese companies have traditionally been competitive in producing low-value, labor-intensive goods but recent Five Year Plans have sought to move China up the value chain in manufacturing. China's leaders want to move away from a dependence on foreign technology. They want China to become a leader in technological innovation. The components of this effort include sustained investment in research and education, government investment in strategic industries, and, as part of the economic opening, a sustained effort to acquire western technology through means both licit and illicit.

Between 1995 and 2002, China doubled the percentage of its GDP invested in R&D, from 0.6 to 1.2 percent. China says that it intends to double the proportion of science spending devoted to basic research to about 20 percent of its science budget, in the next 10 years. China's effort to become an advanced technological power has had uneven success and the rate of return on the massive investment is low. Official statistics are misleading. China remains a net importer of advanced technology. But in the last few years there have been significant improvements and the trend is for these improvements to continue. China is becoming a center for research and development and is home to a skilled technology workforce.

To compare China and the U.S., China has engaged in a sustained investment in technology for thirty years while U.S. investments in science have too often come in fits and starts and been driven by fads. China's policy to maintain and increase economic growth has many flaws, but at

least they have one, and the contrast is beginning to tell. A centrally directed economy subject to heavy political interference can be remarkably inefficient in making investment decisions and in production, but China has compensated for this with heavy and sustained government spending to build capacity and by drawing upon an immense and underutilized talent pool.

Unwillingness by Western countries to press China to comply with its WTO commitments creates an opportunity that China has been quick to seize, but even if it complied fully, Chinese firms would still be formidable competitors in a growing range of industries. China's justification for evading its WTO agreements and engaging in a massive program to illicitly acquire western technology is that it is still a poor and developing economy, that the West owes it for the "Century of Humiliation," and, reflecting Mao-era propaganda, that the U.S. is innately hostile, seeking to encircle China and thwart its growth in order to preserve American hegemon. None of these arguments make any sense, but in China's closed political environment, these assertions will not be subject to scrutiny or debate.

Even as late as a decade ago, most Chinese weapons systems were not globally competitive. But sustained investment in R&D and in defense acquisitions (along with a healthy dose of espionage) and the larger improvements in Chinese manufacturing capabilities have changed this. While most Chinese weapons are not yet as good as top of the line western systems, they are good enough for many buyers and priced significantly lower. China has used this model – national champions with strong government support offering good-enough products at much lower cost - to capture global markets in other industries. China used to service the "bottom feeders" in the global arms market – countries that didn't care about quality and mainly wanted low prices or countries whose ability to buy arms was constrained by international sanctions. This is changing as China's weapons improve.

We can assess China's defensive industrial base by examining its performance and improvement in eight areas that are crucial for building modern weapons. These are:

- A strong R&D base, especially for basic research
- An ability to turn R&D into innovations and new products
- An ability to turn commercial innovation into military equipment
- Component Integration and manufacturing skills
- Databases and experience in weapons production
- Access to a robust national and international supply chain for components and technology
- Access to advanced technology for manufacturing, material, sensors, software, microprocessors and other advanced technologies.
- Doctrine and training to incorporate new technologies into military operations.

China has shown improvement in all of these areas, but the most important factors for explaining China's improved weapons production are its improved manufacturing capability and access to international sources for components and technology, through commercial channels and through espionage.

It is the improvement in China's indigenous production capabilities in combination with access to foreign technology that drive the increased quality of Chinese products. Except in a few areas,

such as missiles, Chinese indigenous applied research development capabilities are not yet sufficient to build modern weapons, but their manufacturing capabilities are no longer an obstacle to production. This reflect a larger trend in the Chinese economy, where Chinese companies that seek to compete in the global market have steadily improved and are likely to continue to do so.

China's improved manufacturing quality results from a transfer of skills. Foreign Direct Investment (FDI) has been the largest source of technology transfer for China. When western aircraft companies create co-production facilities in China, they teach Chinese workers how to build planes to Western standards. This can include machining tolerances, quality of welds, and the general care taken in producing components and assembling them into an aircraft. Compare the Y-12 of the 1980s to the current Y-12F or to China's new ARJ21, which integrates components from more than a dozen western manufacturers. China does not yet have a fully indigenous capability to build modern aircraft - its struggles to build a modern jet engines show this – but Foreign Direct Investment has helped to teach Chinese companies to build to global standards.

A simplistic critique would attack this investment, but it is hard to see what a realistic alternative would have been for the U.S. and other nations. First, FDI has generated immense revenue for western countries. China's rise makes the world wealthier. Second, even if the U.S. had blocked FDI, other nations with advanced aircraft manufacturers would not. Finally, FDI was predicated on a very different bilateral relationship in the 1980s and 1990s, one that assumed China becoming less hostile and playing by the rules of world trade as it was integrated into the global economy. How China will incorporate itself into international affairs and the role it will play remains an open question.

Skills gained from manufacturing commercial aircraft can be transferred to building military production. China's improvements in building military aircraft is reinforced by close commercial relationships with key arms suppliers in Russia, Israel and Europe. It is also accelerated by a program of intensive industrial espionage aimed at U.S, Russian, and European manufacturers.

Russian sales and agreements have been the most important for China's military production. Russia sells advanced weaponry including fighter aircraft, and agreed to their assembly in China from kits. China has reverse-engineered these weapons. Israel provided advance avionics and helped in aircraft design. Transfers have taken place in fits and starts over the last twenty years, as Russia would contract exports over worries about building Chinese capabilities and as Israel responded to external pressure, but the overall effect has been to make a significant contribution to China's military aircraft production capabilities.

Russia's experience with the Sukhoi 27 is illustrative. Russia agreed to China assembling under license 200 SU-27s from kits. The price was reportedly $2.5 billion. Halfway through project, China revealed a prototype named the J-11, which looks exactly like the Su-27. China claimed the aircraft was developed indigenously, but Russia cancelled the assembly license. There are more recent reports that the Su-30, another advanced Russian fighter, has also been copied. Russia also suspects that China's tank and conventional submarines are based on Russian

designs. China is a multi-billion dollar customer for Russian arms, so despite their unhappiness over the Su-27, Russia agreed to resume sales of advanced weapons last year.

These commercial transfers have been reinforced by an energetic espionage program that began with China's economic opening to the West in the early 1980s and moved into cyberspace at least twelve years. There is often a lag between the loss of technology to China through espionage and the appearance of a competing weapon systems, and espionage is only a part of the China's larger effort to acquire technology and build advanced weapons, but an example of a sustained campaign might be China's acquisition of part of an F-117 stealth aircraft shot down by the Serbs in 1999, the hacking and exfiltration of important data from a U.S. military facility engaged in research on stealth aircraft in 2002, and the loss of F-35 technology from a contractor in 2007. These were accompanied by heavy investment in materials research and manufacturing and in aerospace research, but it is likely that it would have taken years longer for China to produce its own stealth fighter without it successful and targeted espionage campaign.

Technological espionage has carried over into cyberspace, as the Chinese discovered that the internet gave them unparalleled access to poorly secured western networks. Cyber-espionage has given China access to defense-industrial databases, the record of previous weapons programs and an invaluable resource. These databases provide the historic experience of building weapons. They show design changes, modifications, how production problems were overcome, and testing result. Since many of these data bases are stored digitally, cyber espionage has given China access to them. The value of access to databases is increased as China acquired the know-how trough co-production and education, creating the human capital that can understand and take advantage of data. .

Cyber espionage has been and continues to be a godsend to China's economic and technological modernization. For military equipment, a 2012 Defense Science Board report identified a range of systems as compromised by Chinese espionage. These included the PAC-3 Patriot missile system, Terminal High Altitude Area Defense (THAAD); the Aegis ballistic-missile defense system, the F/A-18 fighter jet, the V-22 Osprey, the Black Hawk helicopter, the F-35 Joint Strike fighter and the Littoral Combat Ship (LCS). These targets not only improved China's own manufacturing capabilities, but provided it insight into air and air defense system most likely to be used in combat a maritime and air combat and allowed China to try to develop countermeasures to evade or defeat US missile and air defense.

This is by no means complete list. China duplicates this pattern of sustained investment, external sources for technology, and espionage in building other weapons systems. There are reports of successful efforts to acquire technology related to air-to-air missiles, helicopters, submarine technologies, sensors and nuclear weapons. Cyber espionage is accompanied by collection efforts by human agents, both in China and in other countries, but over time the most rewarding collection programs have shifted from human agents targeting western facilities locate din China to cyber espionage. Military, research, and economic policy-making bodies can task collection but China is reportedly moving centralize tasking procedures. There appears to be a limited correlation between goals set in the Five year plans and espionage targets.

China is a leading global practitioner (although by no means the only practitioner) of cyber

espionage, but its forte is economic espionage. Chinese government agencies, companies, and individuals use cyberspace to illicitly acquire technology or gain business advantage. The head of the British Security Service warned companies that hacking is a routine business practice in China.[1] China's cyber espionage efforts combine official programs with coordination of efforts of individuals, companies, and civil agencies as collectors. This broad, diffuse, cyber espionage collection program reflects China's approach to intelligence collection – instead of relying on officers operating under official cover, China's uses what been described as "a thousand grains of sand," where businessmen, researchers or students are asked to collect information when they visit another country.[2]

Chinese companies are also a target for cyber espionage by Chinese hackers.[3] Economic espionage reflects deep political and perhaps cultural issues as well as entrenched economic interests. Some Chinese hacker groups, including groups affiliated with the PLA, will carry out their official missions during the day and then hack for profit at night. Other hacking groups will come across commercially valuable information as they carry out their official espionage tasks, take it, and then sell it for a personal profit to Chinese firms. Economic espionage is a money making activity for the PLA, and this increases the difficulty of bringing it under control.

There is a growing realization in parts of the Chinese government that the lack of strong IP protections does serious damage to China's ability to innovate. Stealing western technology compensates for this inability to create, but it also reinforces the trends that harm China's own efforts to expand innovation. The government recognizes that piracy and weak IP protection undercut indigenous innovation, but is unsure how to proceed. This ambivalence is at the core of one of China's largest policy problems – move closer to global or western standards or impose a national approach that benefits China (and the Party). A decision by China's leaders on cyber espionage is complicated by implications for domestic politics. A misstep could damage support for the regime. The touchstone that guides China's policy decision is whether something produces the continued fast growth that the leadership believes is crucial for domestic stability and their political survival.

No one can object to a country trying to increase its innovative capabilities or research productivity, but it is the methods China uses that are a problem. In addition to investment in science and engineering, China aggressively pursues illicit technology transfer and intervenes to support Chinese firms against foreign competitors. Illicit acquisition of foreign technology has been promoted by the government policy since China opened its economy, but it also reflects societal attitudes towards intellectual property. One reason China does not have a strong domestic software industry, for example, is that no Chinese company can survive the wholesale pirating of its products.

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[1] Times of London, "Jonathan Evans alert on China's cyber spying," December 1, 2007 http://business.timesonline.co.uk/tol/business/industry_sectors/technology/article2980250.ece

[2] See, for example: Northrop Grumman Corporation, "Capability of the People's Republic of China to Conduct Cyber Warfare and Computer Network Exploitation, http://www.uscc.gov/researchpapers/2009/NorthropGrumman_PRC_Cyber_Paper_FINAL_Approved%20Report_16Oct2009.pdf

[3] Office of the National Counterintelligence Executive, "Foreign Spies Stealing Us Economic Secrets in Cyberspace, October 2011, http://www.dni.gov/reports/20111103_report_fecie.pdf

Cyber espionage is best seen as the leading component of a larger economic espionage effort. Since the 1980s, technology transfer China's decision to open its economy in the 1980s included instructions to make technology transfer to Chinese partners a part of every major business negotiation. In a discussion in June of last year in Beijing, a US official said that espionage for national security purposes was a legitimate activity for great powers like the U.S. and china, but that economic espionage was not, and should stop. A PLA officer responded that for China, economic growth and building China's technological base were national security issues, and therefore justified.

Other Asian countries have used similar policies to build industrial capacities, but they usually brought their policies into line with global IP protection norms within two or three decades. China shows no sings of doing this. China does not seem to be making this transition, for reasons of both domestic politics and international strategy. Technology transfer to China that expanded China's productive capabilities would be in the West's interest if China protected intellectual property protections and if important segment of China's decision making elite, including in particular the PLA, were not so antagonistic.

Espionage reinforces and accelerates the improvement of China's manufacturing capabilities. But even without espionage, China would develop advanced manufacturing capabilities. Espionage may even retard the development of indigenous capabilities to a degree, by discouraging IP creation. If China had not illicitly acquired technology, its national income would have probably recovered as quickly in the Post-Mao recovery, but it would not have made the strides towards technological parity with the west its leaders wanted for reasons of prestige and defense. The effect of illicit acquisitions has been to accelerate technological improvement and increase China's international competitiveness. The argument that the U.S. engages in similar activities in the 19th century is simply a distortion of history.

For defense industries, the combination of sustained investment and foreign technology inputs has significantly improved China's arms production capabilities, moving it from building museum pieces to modern weaponry that in some categories is as good or almost as good as western arms. The sanctions on arms exports imposed after the Tiananmen massacre pose less of an obstacle to China's defense industrial improvements very year. China continues to object to them and would be willing to buy Europeans weapons ((opening up the possibility of reverse engineering. European manufacturers know that China has become one of the largest arms importers in the world. But the most important reason that Tiananmen sanctions have less effect is that they do not stop the sale of advanced commercial technologies than can contribute to military production.

Many countries have tried to build advanced arms and failed. It is not an easy task. But if a country is willing to spend billions of dollars for decades and is ruthless in acquiring technology, it can succeed. Of all the developing countries, China is the only one to show signs of succeeding. This is perhaps a legacy of the Party's Leninist inheritance and the priority Lenin gave to defense production. But we need to recognize that as China's economy modernizes, so will its defense industrial capabilities, with or without foreign assistance or Chinese espionage.

China will not change its behavior until there are threats and penalties. Congress can create

these. There are few rewards left to give, perhaps the only one is formal recognition of market economy status, which should not be granted until there has been significant progress in reducing economic espionage. Congressional action to compensate for China's growing defense production capabilities could occur in four areas.

- Congress could look for ways to make the U.S. a more business friendly environment. rationalizing the tax code, controlling non-discretionary spending, and streamlining regulatory burdens.
- Congress could create incentives and penalties to encourage American companies to increase their network defenses. DOD has begun to do this using its contracting authorities.
- Congress could provide sustained funding for the hard sciences, and for science and engineering education at the undergraduate and graduate level. It sometimes appears that Americans have forgotten the central role defense R&D played in American economic growth from 1950 to 1990.
- Congress and the Administration need to take steps to reduce economic espionage. The argument that the Snowden leaks create parity between the US and China is ridiculous, like saying that U.S. spying on political and military targets in China justifies the PLA pillaging our industries. China will use Snowden leaks for political advantage, but since they already assumed we were spying on them the leaks had little effect on their actual policies or negotiating positions. The best strategy would be multilateral, with many countries giving Beijing the same message: this not responsible state behavior.

U.S. policy is to encourage competition in global markets, and China as an economic competitor is a welcome addition to the global economy. Where our policies erred was in assuming that China would follow international practice in trade and that it would become a partner rather than a potential military opponent. Chinese leaders are ambivalent about their relation with the U.S. If we just had to deal with Chinese industry and economic policy-makers, the only real issue would be winning greater compliance with WTO commitments and ensuring fair conditions for competition, but they are not the drivers of Chinese policy and the PLA remains insular and deeply hostile. China can be independent, rich and powerful without being antagonistic, but this would require significant change in the Party's thinking about international affairs. A renewed U.S. partnership with China remains possible, but will require energetic and assertive diplomacy.

Yuan Shikia, the Qing General who overthrew the last Chinese emperor in 1912, said that the way to restore China's prestige and power was to build "a wealthy nation and a strong army." China's current leaders could easily agree with this statement. China has been able to close the technology gap much more rapidly than expected. China is better able to make use of the technology it acquires licitly or illicitly. China's own R&D capacity is improving as a result of sustained investment. Cyber espionage against technology and commercial targets continues unabated. And in the long term, China's commercial growth will continue to drive improvement in manufacturing capabilities that will improve the defense industrial base.