

Issue Brief

# Chokepoints

China's Self-Identified  
Strategic Technology  
Import Dependencies

---

**Author**

Ben Murphy

## Introduction

Speaking to Chinese scientists in September 2020, President Xi Jinping of the People’s Republic of China warned that the PRC is at the mercy of foreign countries that supply it with “chokepoint” technologies. “We rely on imports for some critical devices, components, and raw materials,” he said.<sup>1</sup> PRC leadership concerns about strategic technologies are not new. Many Chinese policy documents issued in the last several years identify categories of technology with particular importance for PRC national security and economic competitiveness.<sup>2</sup> And others, notably China’s 2016 *National Innovation-Driven Development Strategy*, fret that certain “key and core technologies are controlled by others,” a phrase that Xi also frequently uses.<sup>3</sup> However, as a rule, these policies and other PRC state-run media content rarely go into detail about exactly which “key and core technologies” (关键核心技术) are “controlled by others” (受制于人), nor do they specify just who these “others” are.

This issue brief describes a notable exception to this rule: a series of detailed articles on “chokepoint” technologies that a PRC government-run newspaper, *Science and Technology Daily* (科技日报), published in 2018. The series, which has gone largely unnoticed in the non-Chinese-speaking world, speculates in detail about the effects—positive and negative, short- and long-term—on China if named foreign providers cut off the supply of specific “chokepoint” technologies. The articles also examine the reasons behind China’s import dependencies, and some of those they identify may surprise U.S. observers. Key points include:

- China’s most acute “chokepoints” are technologies—particularly high-end electronic components and specialized steel alloys—dominated by one or a handful of companies based in the United States or other like-minded democracies.
- Rather than playing for the “national team,” Chinese companies—both private and state-owned—often prioritize their brands and bottom lines over marching in lockstep with Beijing’s industrial policies. Many PRC firms choose to buy vital

high-end components from trusted foreign suppliers because they harbor doubts about the quality of goods provided by domestic vendors.

- Technological breakthroughs made by Chinese universities and research institutes frequently fail to find commercial applications, leaving the PRC market dominated by foreign products.
- The articles assert that China is making progress on import substitutions for many of these technologies through a combination of strategies including homegrown innovation, reverse engineering, and corporate acquisitions.

### The “Chokepoints” Article Series

*Science and Technology Daily* (henceforth “S&T Daily”), which is affiliated with the PRC Ministry of Science and Technology, published the “chokepoints” article series in 2018.<sup>4</sup> Each of the 35 articles in the series is written by one or more *S&T Daily* staff reporters and profiles a different technological import dependency for China. Every article quotes PRC academics, industry insiders, and other experts who describe how the technology works and why China struggles to produce it domestically. The article series is—along with the regular reports filed by PRC S&T diplomats overseas—one of the few publicly available state-affiliated sources to address the specific foreign technologies that China seeks to acquire.<sup>5</sup>

The series is entitled “What Are Our Chokepoints? Core Technologies We Urgently Await Breakthroughs In.”<sup>6</sup> *S&T Daily* published the 35 articles from April through July of 2018. An editor’s note to the first article, echoing the PRC official stance, states that “compared with developed countries, China has a lot of fields in which the key and core technologies are controlled by others,” and explains that the series will identify these technologies and discuss where “breakthroughs can be made.”<sup>7</sup> This focus on technological self-sufficiency echoes PRC industrial policies such as *Made in China 2025*, which aim for “independently controllable” (自主可控) production chains for as many strategic technologies as possible.<sup>8</sup>

## Why S&T Daily Matters

A key reason why the “chokepoints” series is more significant than similar lists of import dependencies circulating on the PRC internet and social media lies in S&T Daily’s affiliation with the Chinese Communist Party and the PRC government.

S&T Daily claims to be “the main propaganda front for the CCP Central Committee and the State Council”—the executive branch of the PRC central government— “in the S&T realm.”<sup>9</sup> It is a Chinese-language weekday newspaper published by Science and Technology Daily Publishing House (科技日报社) and is China’s “only national-level S&T media outlet,” according to an explainer on the paper’s website.<sup>10</sup>

Specifically, the Ministry of Science and Technology reviews and approves all S&T Daily content. MOST is “entrusted with the management of” Science and Technology Daily Publishing House, per the S&T Daily website.<sup>11</sup> Li Ping (李平), chairman of the publishing house, is a member of MOST’s Party Group—composed of the highest-ranking CCP members in the ministry, who ensure that MOST and its employees obey all Party directives—and is therefore a close subordinate of PRC Minister of Science and Technology Wang Zhigang (王志刚), who heads the group.<sup>12</sup>

Li and Science and Technology Daily Publishing House are responsible for S&T Daily’s content, and they are both subject to oversight by the ministry. Although the articles in the “chokepoints” series do not necessarily represent the official views of MOST,<sup>13</sup> the fact that the ministry allowed their publication indicates that MOST judges that the CCP approves, or at least tolerates, the content of the series.<sup>14</sup>

According to its website, S&T Daily’s target readership includes officials at PRC central government ministries and commissions, as well as at provincial-level S&T departments. Its readership also includes PRC scientific research institute personnel, employees of tech companies, university professors, employees of large hospitals, and foreign scientific researchers and corporations.<sup>15</sup>

### Scope Note and Caveats

1. This issue brief does not attempt to verify the accuracy of the viewpoints expressed in the “chokepoints” article series in any systematic way. Evaluation of the validity of the arguments made in all 35 articles is beyond the scope of this paper.
2. The fact that the article series was published by a PRC government newspaper does not necessarily indicate that the reporting in the articles is truthful.
3. While *S&T Daily*’s affiliation with the PRC government gives this series of articles a bit more weight than other Chinese lists of “chokepoint” technologies, it is by no means the only PRC media source that attempts to identify Chinese technological import dependencies.
4. The “chokepoints” articles were all published in 2018. This issue brief does not attempt to update the information provided by the article series in any systematic way or to verify which “chokepoints” are still relevant in 2022.
5. The articles focus on technologies that China imports. They do not discuss China’s reliance on imported raw materials or commodities.
6. Although all 35 technologies profiled in the series are dual-use, the articles focus on civilian uses of each technology and generally touch on military applications only briefly or not at all.

## S&T Daily Article Series: Some “Chokepoints” are Worse than Others . . .

Based on a review of all 35 articles in the series, some “chokepoints” appear to be more of a threat to the PRC economy and Chinese national security than others. The authors of some articles note that only one or a handful of foreign companies “monopolize” the strategic technology in question. In others, the authors lament that no Chinese suppliers have any market share in a particular “chokepoint” technology, or the article does not mention any PRC firms working on the technology at all. A handful of articles in the series speculate about what would happen if China lost all access to one of these strategic imports due to foreign sanctions or a trade embargo, and some of these scenarios are quite pessimistic from the Chinese perspective.

Table 1, below, lists 14 technological import dependencies that the Center for Security and Emerging Technology (CSET) assesses are the most vexing for China, based on the evidence presented by the articles’ authors. (For more details on all 35 articles, including the less daunting “chokepoints,” see the Appendix.) According to the “chokepoints” authors, each of the 14 technologies listed in Table 1 has the following characteristics:

- A. The technology is the exclusive preserve of one or a handful of companies based in North America, Europe, or Japan;
- B. Zero—or very few—commercial Chinese providers of lower-end versions of the technology are making progress developing high-end versions that can compete with the world’s leading technologies;
- C. Other factors, described by the authors, make Chinese import substitution for the technology unusually difficult.

Table 1: S&T Daily’s Analysis of China’s Most Acute “Chokepoints”

Technology	Area of Application	S&T Daily’s Explanation of the “Chokepoint”
<b>(1) Photo-lithography machines</b>	Microchips	Just one company in the world, ASML in the Netherlands, “monopolizes” top-performing photolithography machines. German company ZEISS makes the lens elements, the “heart” of ASML’s machines. It took ZEISS “decades, if not centuries” to refine the lenses to their current precision and material uniformity. Even if ASML gave away the blueprints for its photolithography machines, PRC manufacturers would not be able to replicate them [due to the large amount of tacit knowledge required].
<b>(26) Underwater connectors</b>	Underwater observation networks, offshore oil and gas extraction	There are no “usable” PRC domestically produced wet-mate connectors (which can be connected and disconnected while underwater). U.S. company Teledyne ODI manufactures “almost all” wet-mate connectors currently used in the construction of seafloor observation networks. China needs these connectors for the ongoing construction of its national seafloor observation network.
<b>(6) Vacuum evaporators</b>	High-end OLED displays	Japanese company Canon Tokki is to high-end vacuum evaporators what ASML is to photolithography machines. Each vacuum evaporator costs over \$100 million, and Canon Tokki only produces a handful to a dozen each year, so China cannot buy enough to meet its needs, even with unlimited funds. [The article does not mention any PRC manufacturers of high-end vacuum evaporators.]
<b>(18) High-end bearing steel</b>	Aircraft, cars, high-speed rail, precision machine tools	Chinese high-performance axles are among the best in the world, but the PRC “depends on imports” for “almost all” of the high-end bearing steel in these axles. Two companies, TimkenSteel in the United States and SKF in Sweden, “basically monopolize” high-end bearing steel manufacturing. [The article does not mention any PRC manufacturers of high-end bearing steel by name.]

<b>(7) High-end radio frequency (RF) components</b>	Mobile phones	U.S. companies Skyworks, Qorvo, and Broadcom “monopolize” the high-end market for the “key” RF component, the power amplifier chip (or RF chip). There are “essentially” no Chinese firms at all in the high-end RF chip market. U.S. manufacturers such as Qorvo “entirely” dominate the market for another class of RF components: high-end wave filters used in mobile phones.
<b>(25) Microspheres</b>	LCD panels, microchips, pharma	Only “one or two” Japanese companies produce the spacer microspheres and conductive gold microspheres necessary for LCD panel manufacturing. Sekisui Chemical “monopolizes” conductive gold microspheres. Chinese microsphere manufacturer Suzhou NanoMicro (苏州纳微科技公司) is catching up in the area of pharmaceutical-use microspheres, but it still has to import foreign raw materials and reaction kettles to produce its microspheres.
<b>(9) Heavy-duty gas turbines</b>	Power grid, large power stations	GE, Mitsubishi, Siemens, and Italian company Ansaldo sell heavy-duty gas turbines (50 MW or more) to Chinese companies. These turbines account for only 3 percent of China’s total power generation capacity, but this small percentage is an “irreplaceable” one, because heavy-duty gas turbines start and stop quickly, are more efficient, and have low emissions. China relies on foreigners for core manufacturing technology, operations and maintenance, and spare parts. “When it comes to so-called ‘chokepoints,’ this is as bad as it gets.”
<b>(20) Aviation design software</b>	Aircraft	The various kinds of aviation design software— aerodynamics software, structural design software, system design software, and assembly software—are “all products from countries in Europe and North America.” Designing both civilian and military aircraft is impossible without them. Aviation design software is essentially a “skull-squeezing curse”; <sup>16</sup> if foreign companies stop providing China with the software, the PRC aviation industry will be “paralyzed.” Chinese Professor Yao Weixing (姚卫星) of Nanjing University of Aeronautics and Astronautics



		(南京航空航天大学) has developed a world-class structural fatigue analysis software program, but as of yet, “no domestically produced software can be seen in circulation and use in the market.”
<b>(24) Main bearings for tunnel boring machines (TBM)</b>	Tunnels	Just four companies in the world make main bearings for TBMs: ThyssenKrupp Rothe Erde, IMO, and FAG in Germany, and SKF in Sweden. Of these, Rothe Erde is the leader; it has the majority of global market share for full-face TBMs. If the main bearing fails, it is “unfeasible” to repair on site, so PRC TBM manufacturers prefer to pay high prices for the best. China spends nearly \$150 million annually importing main bearings. China has “mastered” 3m diameter bearings, but cannot yet produce bearings large enough—7m in diameter—for the biggest TBMs.
<b>(33) High-strength stainless steel (for rocket engines)</b>	Missiles, satellites, spacecraft	China is still in the “copying” (仿制) stage of aerospace-grade stainless steel new materials R&D. [This article is unique among the 35 in the “chokepoints” series in that it does not mention either the foreign companies or countries that manufacture the best high-strength stainless steel. This may be because S&T Daily does not want to flag which firms or countries China is “copying” from.]
<b>(16) Aviation-grade steel (for landing gear)</b>	Large aircraft	China is “considerably” behind the United States and Japan in ultra-strong aviation steel, especially various advanced rolling, cooling, and heat-treatment technologies. China’s annual market shortfall in high-temperature alloys for the landing gear of large military and civilian aircraft is nearly ten thousand tons. Chinese ultra-high-strength steel is “basically the same or slightly better” than Europe’s or Russia’s, but lags behind the United States, particularly in materials innovation and high-purity smelting technology. China is narrowing the gap in high-temperature alloys.
<b>(23) Transmission electron</b>	Biotech, pharma, medicine	There “is not a single” PRC TEM manufacturer. Currently there are only three in the entire world: JEOL and Hitachi in Japan, and FEI Company [now owned by Thermo Fisher

<p><b>microscopes (TEM)</b></p>		<p>Scientific] in the United States. Thermo Fisher employee Chen Baoqing (陈宝庆) recalls “exasperated” PRC researchers who asked him why FEI “did not have relevant patents.” [The researchers probably wanted to glean TEM technology from the details of the patent applications.] “Everything” in PRC cryo-electron microscopy (cryo-EM) labs must be imported: laboratory hoods, small gold sheets, external braces, and so on.</p>
<p><b>(3) Operating systems</b></p>	<p>Mobile phones, PCs</p>	<p>Microsoft and Apple operating system features and patents are the result of years of trial and error; computer programming in general had a 30-year head start in the United States relative to China. PRC electronics industry expert Shi Lei (石磊) says that although Chinese smartphone makers can currently use Android for free, they “may have their food supply cut off at any time.” [The article does not mention any PRC operating system providers.]</p>
<p><b>(29) Lithium battery separators</b></p>	<p>New energy vehicles</p>	<p>China has the “advantage” in low-end lithium battery products, but is “heavily reliant” on imports for high-end battery separator materials. Japanese firms Asahi Kasei and Tonen [now owned by Japan’s Toray Industries] dominate high-end lithium battery separator materials, and Japanese companies such as Showa Denko “monopolize” aluminum-plastic films for these batteries, with 90 percent market share in China. The PRC is already among the best in the world at the dry process for separator manufacturing, and some PRC firms have “mastered” the wet process, but still “depend mainly on imports” for core production equipment.</p>

Source: S&T Daily.

Note: The number in parentheses in front of the name of each technology refers to the number of the article in the S&T Daily “chokepoints” series that profiled the technology in question. The explanations are in the “voice” of S&T Daily, except for sentences in brackets, which are CSET’s observations. For citation information and lengthier summaries of all 35 articles in the series, see the Appendix.

## ... but Sometimes a “Chokepoint” Crisis is Actually an Opportunity

However, the “chokepoints” series also addresses cases where foreign “embargoes” on key technologies will, in the authors’ opinions, actually benefit China in the long run.

Two articles—on microchips and electronic design automation (EDA) software, respectively—assert that although losing access to imports of these key technologies would be very damaging for China in the short term, such crises will give needed impetus to China’s import substitution efforts.

- If the United States and Germany impose a long-term “embargo” on China and cut off access to their EDA software—essential in the manufacturing of higher-performance central processing unit (CPU) microchips in particular—this would spur China toward self-sufficiency, according to Xia Gang (夏刚), a PRC EDA researcher quoted in “chokepoints” article 13. Xia argues that a short ban, by contrast, would actually be worse for China, because Chinese chip makers would first buy pirated versions of foreign software as they waited for the ban to be lifted, rather than making a permanent switch to untested domestic EDA providers.<sup>17</sup>
- The U.S. Department of Commerce’s Bureau of Industry and Security (BIS) hit PRC telecommunications company ZTE with what *S&T Daily* described as a “heavy fist” in April 2018 when it issued a denial order against the company,<sup>18</sup> preventing it from buying the imported U.S. and UK microchips it is “completely reliant” on. Perhaps as early as 2025, however, China will develop a domestic chip ecosystem that can compete with foreign chip ecosystems such as Intel-Microsoft and Arm-Android and weather any foreign “embargo,” according to Hu Weiwu (胡伟武), a computing industry expert quoted in the article.<sup>19</sup>

## S&T Daily Highlights Some Surprising Reasons for Import Dependencies . . .

Each of the “chokepoints” articles explores the factors that spur Chinese imports of the strategic technology in question, and some of these—notably many PRC companies’ preference for foreign high-end components—may be counterintuitive to U.S.-based China watchers.

While it’s tempting to view the authoritarian People’s Republic of China as a monolith ruled from the top down by the Communist Party, many of the “chokepoints” articles portray Chinese firms as caring more about their brands and bottom lines than about playing for the “national team” and buying from domestic suppliers. In cases where the cost of failure is very high, PRC manufacturers will frequently pay a premium for high-end imported components because **they view domestic versions as unreliable**, according to *S&T Daily*.

- Yang Huayong (杨华勇), a PRC expert on underwater connectors, told *S&T Daily* that Chinese oil companies “will not use” untested domestically produced wet-mate connectors, because any failure causes “huge economic losses.” These connectors are also necessary for China’s construction of a seafloor observation network in the South and East China Seas, and any “embargo” on the U.S. and German high-quality imported connectors required will bring this project, vital to PRC “national security,” to a halt.<sup>20</sup>
- Chinese tunnel boring machine (TBM) manufacturers spend nearly \$150 million a year importing main bearings for these machines, according to one article. PRC railway tunnel expert Mei Yongbing (梅勇兵) told *S&T Daily* that if a bearing breaks, it is “unfeasible” to repair it on site, so Chinese TBM producers “would rather pay the high prices” for foreign “name-brand main bearings,” rather than rely on newer, untested domestic providers.<sup>21</sup>
- “Chokepoints” article 14 reports that Chinese flatscreen display makers are “addicted” to imports of high-end indium tin oxide (ITO) sputtering targets—used in the manufacturing process for flat panel displays and touchscreens—for their top-of-the-line products. Domestic ITO targets have “inconsistent batch

quality” and PRC panel manufacturers choose imports to “save themselves trouble.”<sup>22</sup>

- “Out of an abundance of caution,” PRC banks, telecom companies, electric utilities, and other firms with “extreme dependability requirements” refuse to switch to domestic database management systems (DBMS) and prefer to continue using systems from U.S. companies such as Oracle, another article says.<sup>23</sup>

Several other “chokepoints” articles argue that PRC domestic technology development often stalls due to a **disconnect between public research institutions and private Chinese companies**. This finding echoes previous CSET research on the robotics industry. In most industrialized nations, companies are by far the most prolific filers of robotics patents, but in China, universities account for the overwhelming majority of patent filings. This raises the question of whether these PRC academic patents are finding commercial applications.<sup>24</sup> The CCP is well aware of this issue. Xi Jinping conceded that China’s “capacity to convert S&T achievements into practical applications (科技成果转化) is weak,” and the 14th Five-Year Plan proposes several measures designed to help bridge the divide between inventors and companies.<sup>25</sup>

- “Chokepoints” article 20 claims that there is no domestically produced aviation design software available on the PRC market. This is despite the fact that Professor Yao Weixing (姚卫星) of Nanjing University of Aeronautics and Astronautics (南京航空航天大学) developed structural fatigue analysis software that is “recognized in the industry as a ‘secret to success.’” State-run research institutes and private (民营) software companies need to improve their cooperation to avoid this type of situation, according to the author.<sup>26</sup>
- China currently relies on expensive imported European high-end welding power sources and technicians for its underwater welding robots, used to construct and maintain facilities such as offshore oil rigs and nuclear power plants, according to another article. Although South China University of Technology (华南理工大学) in Shenzhen recently made a technological breakthrough in this area, a professor at the university, Wang Zhenmin (王振民), says that “the vast

majority” of Chinese welding equipment manufacturers “have almost no R&D capabilities.”<sup>27</sup>

- PRC universities and research institutes, rather than companies, conduct most of the R&D on key materials for fuel cells—a vital component of new energy vehicles—according to “chokepoints” article 27. Chinese companies are still in “wait-and-see” mode. As a result, China has “almost no” fuel cell key component manufacturers and “has long relied” on imports of key fuel cell materials.<sup>28</sup>

In a few instances, **Chinese environmental regulations** are key drivers of demand for foreign technology, according to the “chokepoints” authors.

- After China implemented its National Stage IV Vehicle Pollutant Emission Standards in 2014, PRC automotive diesel engine manufacturers “basically all” adopted high-pressure common rail direct fuel injection systems, a cleaner diesel technology, one article claims. PRC diesel engine expert Meng Xiacong (蒙小聰) told *S&T Daily* that U.S., German, and Japanese manufacturers provide the “lion’s share” of the electronically controlled common rail systems for the Chinese market.
- The author of one article notes that the advantages of heavy-duty gas turbines for China’s power grid are that they start and stop quickly and that they emit relatively low levels of pollution. The article states that the four leading producers—GE, Mitsubishi, Siemens, and the Italian company Ansaldo—are all foreign.<sup>29</sup>

Finally, despite China’s large population, authors of a handful of the “chokepoints” articles call out a **lack of talent** as another reason why the PRC has thus far failed to substitute for imports of certain strategic technologies.

- Wang Zhenmin, in the article on underwater welding power sources cited above, points out China’s “grossly inadequate pool” of “professional welding talent.” Development of cutting-edge power sources requires experienced talent, and yet, over the past decade, many Chinese colleges have eliminated their welding programs, according Wang.<sup>30</sup>

- China is reliant on imported U.S. high-end radio frequency (RF) components—used in mobile phones—per “chokepoints” article seven. China lacks designers “who are familiar with the corresponding specialized processes and packaging” of these components.<sup>31</sup>

## ... and some Not-so-Surprising Reasons behind PRC Import Dependencies

Over the course of its 73 years as China’s dominant political party, the CCP has successfully acquired—through all methods at its disposal—numerous foreign technologies helpful for China’s economic development and military modernization. In the artificial intelligence industry, for example, previous CSET research has described the various legal, extralegal, and illegal avenues that China has pursued to obtain cutting-edge technology from abroad.<sup>32</sup>

China’s remaining import dependencies, as a result, largely involve technologies that **cannot easily be bought or copied**. Several of the “chokepoints” articles say as much.

- Multiple PRC semiconductor experts told *S&T Daily* that even after “costly trial and error” and investments of \$1 billion or more, PRC efforts to develop high-end microchip manufacturing may not succeed. According to one such expert, Li Guojie (李国杰) of the Chinese Academy of Engineering (CAE), China cannot catch up “just by throwing money at” the problem.<sup>33</sup>
- The PRC has been unable to reverse engineer U.S.- and Japanese-made polishing discs for ultra-precision polishing machines, and their material composition and manufacturing techniques remain “mysteries,” one article reports.<sup>34</sup>
- He Rongming (贺荣明), general manager of PRC chip manufacturer Shanghai Micro Electronics Equipment (SMEE; 上海微电子), told *S&T Daily* that an engineer at ASML communicated to him that even if ASML were to give him the blueprints for one of their photolithography machines, SMEE would still be unable to replicate them. He later “understood” this statement to refer to the “decades, if not centuries” of experience and tacit knowledge behind ASML’s products.<sup>35</sup>

- China has been unable to produce usable “knockoff” (山寨版) parts for transmission electron microscopes—used in medicine and biotech—because the world’s three TEM makers treat their production processes as “secret recipes.” Chen Baoqing (陈宝庆), an employee of U.S.-based Thermo Fisher Scientific, told *S&T Daily* that “exasperated” PRC TEM researchers once asked him why FEI Company—a Thermo Fisher subsidiary and TEM manufacturer—“did not have relevant patents.” The researchers were hoping to use manufacturer’s patents as a “shortcut” in developing their own TEMs, Chen explained.<sup>36</sup>

One factor that nearly all of the “chokepoint” technologies *S&T Daily* profiles have in common is that they operate in very demanding environments. They must withstand **extreme stress**, maintain high **batch consistency**, or be manufactured with the **utmost precision**.

- China is reliant on imports for “almost all” of the special steel used for high-end bearings in machinery such as aircraft engines and high-precision machine tools, according to one article. These bearings are subject to extreme stress, friction, and ultra-high temperatures. The author relates the anecdote of an unnamed large PRC state-owned steel conglomerate that had to import bearing steel because its own steel was of insufficient quality for use in bearings in the company’s own equipment.<sup>37</sup>
- Wu Yeqing (吴晔卿), general manager of PRC electronics manufacturer RDCOO SpaceTech (锐迪航科), told *S&T Daily* that big PRC mobile phone brands shun domestically produced capacitors and resistors because of batch consistency problems that can cause phones to charge slower, and prefer to buy these vital electronic components from Japanese manufacturers. PRC resistor and capacitor makers can meet China’s demand for military-grade components and certain specialized resistors, but they have yet to close the “gap” with Japan in consumer-grade, mass-produced capacitors and resistors, Wu contends.<sup>38</sup>
- U.S. and Japanese firms’ mastery of ultra-precision polishing techniques—vital to a variety of industries, including integrated circuit manufacturing—mean that they “control the development” of the global electronics manufacturing industry “to a large extent,” according to another article. The author cites PRC polishing



industry expert Sun Ming (孙明), who says that Chinese suppliers of polishing discs have yet to meet the “extremely demanding” requirements for precision that the technology requires.<sup>39</sup>

As such, the foreign companies that now lead the world in the production of the “chokepoint” technologies required **decades of research, data, and experimentation** to refine their products to their current level. Catching up is therefore a daunting task for PRC latecomers.

- “Chokepoints” article 32 notes that Boeing and Japanese carbon fiber producer Toray perfected the special epoxy used in aerospace-grade carbon fiber during a “breaking-in period nearly 30 years long,” during which the epoxy was “constantly corrected and amended” according to Boeing’s requirements. PRC materials science expert Yu Muhuo (余木火) told *S&T Daily* that Chinese carbon fiber epoxy manufacturers lack this experience, and thus have “inadequate product stability.”<sup>40</sup>
- Chinese IT industry expert Shi Lei (石磊) told *S&T Daily* that U.S. PC and mobile phone operating systems such as Windows, Android, and iOS run quickly, are energy-efficient, and avoid “pitfalls” such as bugs because of years of development experience accumulated through trial and error. The United States used its “early-mover advantage” in this field to gain a “monopoly” on operating systems, the author of the article argues.<sup>41</sup> However, this has not stopped China from trying. PRC telecommunications and electronics giant Huawei, for example, launched its own operating system, HarmonyOS (鸿蒙), in 2019 as a potential alternative to Android.<sup>42</sup>

The “chokepoints” authors write that although the difficulty of the manufacturing process for the “chokepoint” technologies is the main hurdle for China, in some cases, **patent barriers** laid down by the foreign first-movers in these fields are also a factor.

- China’s efforts to catch up in the field of touch sensors for industrial robots are made more difficult by the need for latecomers to “detour around (绕过) the relevant patent protections of the first-movers”—mainly Japanese and U.S. companies—according to one article.<sup>43</sup>

- One “chokepoints” article laments that Japan’s Canon Tokki has 20 years’ worth of patents related to its vacuum evaporators, used in manufacturing high-end organic light-emitting diode (OLED) displays. As a result, Canon Tokki has as much of a “god-like presence” in evaporators as ASML has in lithography, according to the author.<sup>44</sup>
- PRC diesel expert Meng Xiaocong, cited above, says that foreign companies with “almost monopolistic” shares of the Chinese market for high-pressure common rail direct fuel injection systems—used in low-emission diesel engines—have already patented “the vast majority of the key technical points,” per “chokepoints” article 22. Meng complains that it is difficult for China to “detour through” (绕开) these patent barriers.<sup>45</sup>

## How China is Addressing its Import Dependencies

Nearly all of the “chokepoints” articles also offer a hopeful message to *S&T Daily’s* readers about how China can reduce—or is already reducing—its reliance on imported technology. These measures include favorable industrial policies for domestic manufacturers, home-grown innovation, efforts to copy or imitate foreign technology, and acquisition of foreign suppliers. And as previous CSET research has demonstrated, for many “chokepoints,” China adopts a hybrid approach that combines acquisition of foreign technology and breakthroughs at home.<sup>46</sup> See the Appendix for summaries of these measures for each technology.

China is **already on its way** toward alleviating certain “chokepoints,” some of the articles argue.

- PRC diesel engine designer Mo Zonghua (莫宗华) told *S&T Daily* that, starting in 2015, several large Chinese diesel engine manufacturers began buying domestically produced common rail direct fuel injection systems as “supplements or backups” for imported systems. Mo predicted that this will lead to a “big improvement” in the global competitiveness of these Chinese systems.<sup>47</sup>

- “Chokepoints” article 34 reports that many large Chinese companies only trust database management systems (DBMS) from U.S. providers, chiefly Oracle. However, Luo Xiguang (罗曦光) of IBM Analytics told S&T Daily that huge PRC online retailer Alibaba (阿里巴巴) and an increasing number of Chinese startups are building or using domestic cloud services that include DBMS services adapted from open-source DBMS providers rather than using foreign fee-based systems.<sup>48</sup>

In cases where China’s prospects for import substitution in the near term are dimmer, the most common recommendation that the “chokepoints” authors—or the experts they quote—make is for the PRC government to adopt industrial policies favorable to the development of these technologies. In some cases, these policies include **subsidies for and mandated purchases of domestic versions** produced by PRC suppliers.

- The “chokepoints” article on microchips cites Chinese Academy of Engineering (CAE) member Li Guojie (李国杰) and Cheng Hua (程华), a senior engineer at the Jiangnan Institute of Computing Technology (江南计算技术研究所), both of whom urge China (1) to mandate government purchases of domestically manufactured semiconductors and (2) to subsidize domestic chips, just as China previously subsidized the purchase of home appliances by rural households.<sup>49</sup>
- In regards to photoresists—necessary for semiconductor and flat panel display manufacturing—“chokepoints” article 21, citing unnamed “industry insiders” and “experts,” says that the PRC government should “encourage” domestic panel makers to start using Chinese photoresists “as quickly as possible.” Government departments should lay out support policies for the entire photoresist production chain and gather the “stronger enterprises and experts” into an industrial alliance, the article adds.<sup>50</sup>
- The article on high-pressure piston pumps—used in hydraulic machinery for a vast array of industries—cites Chen Qunli (陈群立), an executive at a PRC manufacturer of the technology, who implores the government to provide “policy support” to help bring domestic pumps to market and “substitute for imports.”<sup>51</sup>

Many of the articles assert that China is already on a path to outgrow its technology import dependencies through **homegrown innovation**. In some cases, China is

positioned to take advantage of next-generation technologies and can **leapfrog older techniques** currently dominated by foreign countries, according to the authors.

- Wang Kun (王坤) of the Chinese Academy of Sciences (CAS) Key Laboratory of Molecular Imaging (中科院分子影像重点实验室) told *S&T Daily* that Chinese manufacturers of components for medical imaging equipment have a distinct disadvantage in “traditional” techniques such as computerized tomography (CT) and magnetic resonance imaging (MRI), where U.S. and European companies have a “20-year head start” and many “patent barriers.” But China is “at the same level” as the United States and Europe in the emerging technology of molecular imaging, and Wang’s lab has developed a prototype molecular imager with no foreign components.<sup>52</sup>
- One article cites Chinese intelligent vehicle expert Huang Wuling (黄武陵), who says that China can leapfrog to the cutting edge in light detection and ranging (LiDAR)—a crucial technology for self-driving cars with many military applications—by focusing on the “revolutionary” new technology of solid-state LiDAR. The article says that “almost all” PRC self-driving cars currently use the “industry standard,” namely “traditional 360-degree mechanical rotation LiDAR” supplied by U.S. company Velodyne.<sup>53</sup>
- Jiang Biwang (江必旺), chairman of PRC microsphere manufacturer Suzhou NanoMicro (苏州纳微科技公司), told *S&T Daily* that China relies on imports of spacer microspheres and conductive gold microspheres—used in liquid crystal display (LCD) panels, semiconductors, and biotechnology—because only a handful of Japanese companies have developed technology to sieve the tiny microspheres to uniform sizes. But Jiang claims that his company has developed a “seeding,” rather than “sieving,” method for generating them, “breaking the Japanese technological monopoly.”<sup>54</sup>

In addition to relying on incentives and innovation, China is not above **copying, imitating, or creatively re-purposing** cutting-edge foreign technologies. All of these approaches combine to form an effective, uniquely Chinese system of “re-innovation” (再创新) or “creative adaptation” that repurposes foreign technologies to suit China’s “state-capitalist system.”<sup>55</sup>

- Article 33, on high-strength stainless steel used for rocket engines, cites PRC steel researcher Su Jie (苏杰), who says that China is still in the stage of “copying” (仿制) the world leaders.<sup>56</sup>
- PRC state-owned enterprise Taiyuan Heavy Machinery Group Yuci Hydraulic Industry Co. (太重集团榆次液压工业有限公司) is attempting to catch up to the world leaders in high-pressure piston pumps through “introduction, absorption, and re-innovation” (引进吸收再创新), that is, acquiring and “creatively adapting” foreign technology, according to “chokepoints” article 19.<sup>57</sup>

Finally, a few articles in the series provide examples of how China ameliorated its import dependencies through domestic firms’ **acquisition** of foreign tech companies.

- China relies on imports for certain components of medical imaging equipment, such as scintillation detectors and crystals, one “chokepoints” article reports. But according to the author, one PRC up-and-comer in this industry, Neusoft Medical Systems (东软医疗), made a great stride forward with its “strategic” purchase of an unnamed foreign CT manufacturer in 2017.<sup>58</sup>
- When Illumina—a U.S.-based supplier of reagent kits for individual-nucleotide resolution cross-linking and immunoprecipitation (iCLIP) gene editing technology—“suddenly” raised prices, an unnamed PRC “gene sequencing enterprise” suffered a “huge impact,” another article relates. According to the author, the Chinese company eventually paid “a huge amount” to buy a different foreign firm with expertise in iCLIP primer and reagent technology and subsequently built China’s first domestic gene sequencer.<sup>59</sup> The PRC company in question is almost certainly BGI (华大基因), which bought Complete Genomics, an emerging U.S. rival to Illumina, in 2013.<sup>60</sup>
- “Chokepoints” article 15 laments that the core algorithms of the “big four” industrial robotics companies—all Japanese or European—are far superior to those of Chinese competitors, reflected in a failure rate for PRC robots that is “several times higher” than that of leading foreign competitors.<sup>61</sup> The author fails to mention that Chinese home appliance manufacturer Midea (美的) acquired one of the “big four,” German company KUKA, in 2016.<sup>62</sup>

## Conclusion

In August 2020, Xi Jinping warned an audience of Chinese economists that foreign countries were increasingly resorting to “protectionism and unilateralism,” and “attacking” global supply chains “due to non-economic factors,” as well as generating “more headwinds and countercurrents” impeding China’s development. His response was to advocate a “new pattern of development” (新发展格局)—U.S.-based China watchers often refer to it, inaccurately, as the “dual circulation” strategy—that reduces China’s dependency on export-driven growth and accelerates the country’s transition to a domestic consumption-driven economy.<sup>63</sup>

Xi’s “new pattern of development” has some similarities to the U.S. “decoupling” strategy. But as detailed previously, Chinese concerns about the drawbacks of economic interdependence extend beyond the U.S.-China relationship. The “chokepoints” authors and experts also highlight China’s dependence on Japanese and European suppliers of many key technologies. The common ambition that underlies Xi’s remarks, PRC government documents that emphasize “economic security” such as the 14th Five-Year Plan,<sup>64</sup> and the “chokepoints” series, is, as a recent CSET report puts it, China’s “dream of technological self-sufficiency and dominating in key technology areas.”<sup>65</sup>

A reader of the “chokepoints” articles and related PRC leadership statements may conclude that China is obsessed with S&T self-sufficiency. However, judging whether China truly is more concerned with technological import substitution and self-sufficiency than the United States or other countries is beyond the scope of this paper. The “chokepoints” article series certainly supports the conclusion of the U.S. National Security Director for China, Julian Gewirtz, that China feels “profoundly vulnerable” about its economic dependence on the United States and other nations.<sup>66</sup> But as Jeffrey Ding and Allan Dafoe of the Center for the Governance of AI point out, long before decoupling from China became a hot-button issue, the U.S. government in the 1980s produced multiple studies on how the United States could reduce its reliance on imports of strategic materials and technologies from a different rising technological competitor: Japan.<sup>67</sup> Rather than trying to assess which country is the most eager to

achieve import substitution, a more important question—to be addressed in future CSET research—is which of the technologies profiled in the *S&T Daily* series truly are “chokepoints” that other countries can leverage to influence China’s behavior.

## Author

Ben Murphy is CSET's translation manager.

## Acknowledgments

The author is especially grateful to Scott Harold and Jeffrey Ding for their comprehensive reviews.

The author would also like to thank Yanqi Ding for valuable research assistance, and Catherine Aiken, Zachary Arnold, Owen Daniels, Ryan Fedasiuk, Shelton Fitch, Matt Mahoney, Igor Mikolic-Torreira, Anna Puglisi, Alexander Rubin, Caroline Schuerger, Helen Toner, Lynne Weil, and Emily Weinstein for their suggestions on style and content.



© 2022 by the Center for Security and Emerging Technology. This work is licensed under a Creative Commons Attribution-Non Commercial 4.0 International License.

To view a copy of this license, visit <https://creativecommons.org/licenses/by-nc/4.0/>.

Document Identifier: doi: 10.51593/20210070



## Appendix: Key Details of the 35 Chokepoint Technologies

The Appendix, a table with key details of the 35 “chokepoint” technologies as described by *Science and Technology Daily* and summarized by CSET, is available at:

[https://docs.google.com/spreadsheets/d/1e1qEMe5FDB\\_zvIKcu67CpNK2rIC7UFsa/](https://docs.google.com/spreadsheets/d/1e1qEMe5FDB_zvIKcu67CpNK2rIC7UFsa/)

## Endnotes

<sup>1</sup> The Chinese term that President Xi uses—and that we translate throughout as “chokepoint”—is 卡脖子, which literally means “to strangle” or “to have someone in a stranglehold.” See the original CSET Translation of “Xi Jinping: Speech at the Symposium of Scientists,” Center for Security and Emerging Technology, September 11, 2020, 3, <http://cset.georgetown.edu/research/xi-jinping-speech-at-the-symposium-of-scientists>.

<sup>2</sup> For example, the 14th Five-Year Plan, released in 2021, names research in seven S&T fields as vital to PRC national security: artificial intelligence (AI), quantum, integrated circuits, brain science, biotechnology, clinical medicine, and “deep space, deep earth, deep sea, and polar exploration.” See the original CSET translation of “Outline of the People’s Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035,” Center for Security and Emerging Technology, March 12, 2021, 12-13, <https://cset.georgetown.edu/publication/china-14th-five-year-plan/>. The *Made in China 2025* strategy, issued in 2015, names 10 key fields in need of breakthroughs: new generation information technology (IT), high-end computer numerical control (CNC) machines and robots, aerospace, marine engineering and high-tech ships, advanced rail transport, fuel-efficient and new energy vehicles, electric power generation, agricultural machinery, new materials, and biotech and high-performance medical devices. See the original CSET translation of “Notice of the State Council on the Publication of *Made in China 2025*,” Center for Security and Emerging Technology, March 8, 2022, 19-22, <https://cset.georgetown.edu/publication/notice-of-the-state-council-on-the-publication-of-made-in-china-2025/>.

<sup>3</sup> See the original CSET translation of “Outline of the National Innovation-Driven Development Strategy,” Center for Security and Emerging Technology, December 11, 2019, 2-3, <https://cset.georgetown.edu/publication/outline-of-the-national-innovation-driven-development-strategy/>. Notable Xi Jinping speeches that mention the phrase “key and core technologies are controlled by others” include his May 2018 speech to members of the Chinese Academies of Science and Engineering and his 2020 speech to a symposium of scientists, mentioned above. See “Xi Jinping: Strive to Become the World’s Primary Center for Science and High Ground for Innovation,” translated by Ben Murphy, Rogier Creemers, Elsa Kania, Paul Triolo, and Kevin Neville, DigiChina, March 18, 2021, <https://digichina.stanford.edu/work/xi-jinping-strive-to-become-the-worlds-primary-center-for-science-and-high-ground-for-innovation/> and “Xi Jinping: Speech at the Symposium of Scientists.”

<sup>4</sup> “科技日报社概况” [“Overview of Science and Technology Daily Publishing House”], 中国科技网, [S&T Daily website], July 12, 2019, <https://perma.cc/Y46Q-JZGP>.

<sup>5</sup> For more on PRC S&T diplomats' activities, see Ryan Fedasiuk, Emily Weinstein, and Anna Puglisi, "China's Foreign Technology Wish List" (Center for Security and Emerging Technology, May 2021), <https://cset.georgetown.edu/publication/chinas-foreign-technology-wish-list/>.

<sup>6</sup> “是什么卡了我们的脖子——亟待攻克的核心技术。” A more literal translation of the first part would be “what is it that has us in a chokehold?” or “what is it that is strangling us?”

<sup>7</sup> “Chokepoints” article 1. For full citations for all 35 articles in the “chokepoints” series, see the Appendix.

<sup>8</sup> The *Made in China 2025* strategy, for example, calls for China to achieve “independent assurance” (自主保障) of the supply of 40 percent of the “core basic components and key basic materials” needed for China’s manufacturing industry by 2020, rising to 70 percent in 2025. See “Notice of the State Council on the Publication of *Made in China 2025*,” 15.

<sup>9</sup> “科技日报社概况” [“Overview of Science and Technology Daily Publishing House”], 中国科技网, [S&T Daily website], July 12, 2019, <https://perma.cc/Y46Q-JZGP>.

<sup>10</sup> “科技日报概况” [“Overview of Science and Technology Daily”], 中国科技网, [S&T Daily website], December 29, 2017, <https://perma.cc/E8NJ-JXZ7>.

<sup>11</sup> “科技日报社概况” [“Overview of Science and Technology Daily Publishing House”], 中国科技网, [S&T Daily website]. Most Chinese news outlets, whether state-run or private, have both a “main operational department” (主办部门) responsible for their day-to-day operations and a “main oversight department” (主管部门) with the final say on editorial and censorship decisions. In S&T Daily’s case, Science and Technology Daily Publishing House is its main operational department. MOST is “entrusted with the oversight of” (代管) the publishing house, an unusual wording that suggests MOST’s authority over it is somewhat more indirect than the norm.

<sup>12</sup> “组织结构” [“Organizational Structure”], 中华人民共和国科学技术部 [MOST website], undated, accessed on January 14, 2022, <https://perma.cc/SA9C-RU2K>.

<sup>13</sup> Only certain types of content in S&T Daily are “authoritative” in that they represent the official position of the CCP, the PRC government, or MOST. These vehicles include unattributed editorials (社论) and staff commentator (本报评论员) articles, and speeches by Minister of Science and Technology Wang Zhigang and other top officials at the ministry. The “chokepoint” articles, however, are all attributed to specific S&T Daily reporters and are therefore not authoritative. This gives MOST a degree of plausible deniability, should a top Party leader object to one or more of the articles. The ministry could claim that

the views expressed in the articles are those of the authors, not MOST, and that S&T Daily merely provided a public platform for discussion of them.

<sup>14</sup> Because all PRC media content is subject to censorship, and because the authors and publishers of offending content face punishments including demotion, termination, and prison, PRC media outlets do not publish content they believe the Communist Party leadership will find objectionable. What they do publish is either the viewpoint of the Party or government body that oversees them, or is content they believe said overseeing body will defend if it is challenged by censors.

<sup>15</sup> “科技日报概况” [“Overview of Science and Technology Daily”].

<sup>16</sup> The “skull-squeezing curse” (紧箍咒) is a reference to the 16th-century Chinese novel *Journey to the West*. A major character in the book, the “Monkey King” Sun Wukong, has virtually unlimited magical powers. Only the Buddhist monk Tang Sanzang can restrain the Monkey King, by means of a magical circlet around Sun’s head that tightens at Tang’s command, causing unbearable pain.

<sup>17</sup> “Chokepoints” article 13. See the Appendix for full citation.

<sup>18</sup> BIS terminated this denial order on July 13, 2018, after ZTE paid a \$1 billion civil penalty. See “Order Terminating Denial Order Issued on April 15, 2018, Against Zhongxing Telecommunications Equipment Corporation and ZTE Kangxun Telecommunications Ltd.,” 83 FR 34825, July 23, 2018, <https://perma.cc/F4PG-9AXL>.

<sup>19</sup> “Chokepoints” article 2. See the Appendix for full citation.

<sup>20</sup> “Chokepoints” article 26. See the Appendix for full citation.

<sup>21</sup> “Chokepoints” article 24. See the Appendix for full citation.

<sup>22</sup> “Chokepoints” article 14. See the Appendix for full citation.

<sup>23</sup> “Chokepoints” article 34. See the Appendix for full citation.

<sup>24</sup> Sara Abdulla, “China’s Robotics Patent Landscape” (Center for Security and Emerging Technology, August 2021), 20, <https://cset.georgetown.edu/publication/chinas-robotics-patent-landscape/>.

<sup>25</sup> “Xi Jinping: Strive to Become the World’s Primary Center for Science and High Ground for Innovation” and “Outline of the People’s Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035,” 15-16.

<sup>26</sup> “Chokepoints” article 20. See the Appendix for full citation.

<sup>27</sup> “Chokepoints” article 28. See the Appendix for full citation.

<sup>28</sup> “Chokepoints” article 27. See the Appendix for full citation.

<sup>29</sup> “Chokepoints” article 9. See the Appendix for full citation.

<sup>30</sup> “Chokepoints” article 28. See the Appendix for full citation.

<sup>31</sup> “Chokepoints” article 7. See the Appendix for full citation.

<sup>32</sup> William Hannas and Huey-Meei Chang, “China’s Access to Foreign AI Technology” (Center for Security and Emerging Technology, September 2019), <https://cset.georgetown.edu/publication/chinas-access-to-foreign-ai-technology/>.

<sup>33</sup> “Chokepoints” article 2. See the Appendix for full citation.

<sup>34</sup> “Chokepoints” article 31. See the Appendix for full citation.

<sup>35</sup> “Chokepoints” article 1. See the Appendix for full citation.

<sup>36</sup> “Chokepoints” article 23. See the Appendix for full citation.

<sup>37</sup> “Chokepoints” article 18. See the Appendix for full citation.

<sup>38</sup> “Chokepoints” article 12. See the Appendix for full citation.

<sup>39</sup> “Chokepoints” article 31. See the Appendix for full citation.

<sup>40</sup> “Chokepoints” article 32. See the Appendix for full citation.

<sup>41</sup> “Chokepoints” article 3. See the Appendix for full citation.

<sup>42</sup> Arjun Kharpal, “Huawei launches new operating system, says it can ‘immediately’ switch from Google Android if needed,” CNBC, August 9, 2019, <https://www.cnbc.com/2019/08/09/huawei-launches-its-own-operating-system-hongmengos-or-harmonyos.html>.

<sup>43</sup> “Chokepoints” article 5. See the Appendix for full citation.

<sup>44</sup> “Chokepoints” article 6. See the Appendix for full citation.

<sup>45</sup> “Chokepoints” article 22. See the Appendix for full citation.

<sup>46</sup> Hannas and Chang, 4-5.

<sup>47</sup> “Chokepoints” article 22. See the Appendix for full citation.

<sup>48</sup> “Chokepoints” article 34. See the Appendix for full citation.

<sup>49</sup> “Chokepoints” article 2. See the Appendix for full citation.

<sup>50</sup> “Chokepoints” article 21. See the Appendix for full citation.

<sup>51</sup> “Chokepoints” article 19. See the Appendix for full citation.

<sup>52</sup> “Chokepoints” article 30. See the Appendix for full citation.

<sup>53</sup> “Chokepoints” article 10. See the Appendix for full citation. Other evidence suggests China is also using foreign purchases as a way to catch up in LiDAR. In 2019–2020, PRC S&T diplomats successfully convinced one Chinese firm to purchase LiDAR technology from an Israeli supplier they recommended. See Fedasiuk, Weinstein, and Puglisi, “China’s Foreign Technology Wish List,” 16-17.

<sup>54</sup> “Chokepoints” article 25. See the Appendix for full citation.

<sup>55</sup> See Emily Weinstein, “Beijing’s ‘re-innovation’ strategy is key element of U.S.-China competition,” *Brookings TechStream*, January 6, 2022, <https://www.brookings.edu/techstream/beijings-re-innovation-strategy-is-key-element-of-u-s-china-competition/> and Tai Ming Cheung, William Lucyshyn, and John Rigilano, “The Role of Technology Transfers in China’s Defense Technological and Industrial Development and the Implications for the United States” (U.S. Naval Postgraduate School Defense Acquisition Innovation Repository, February 5, 2019), 10, <https://dair.nps.edu/bitstream/123456789/2756/1/UCSD-AM-19-028.pdf>.

<sup>56</sup> “Chokepoints” article 33. See the Appendix for full citation.

<sup>57</sup> “Chokepoints” article 19. See the Appendix for full citation.

<sup>58</sup> “Chokepoints” article 30. See the Appendix for full citation.

<sup>59</sup> “Chokepoints” article 8. See the Appendix for full citation.

<sup>60</sup> Rebecca Robbins and Kate Sheridan, “A Chinese company unveils a powerful new sequencer. But can it compete in the U.S.?”, *STAT*, October 25, 2018, <https://www.statnews.com/2018/10/25/a-chinese-company-unveils-a-powerful-new-sequencer-but-can-it-compete-in-the-u-s/>.

<sup>61</sup> “Chokepoints” article 15. See the Appendix for full citation.

<sup>62</sup> “About KUKA,” Midea Group website, <https://perma.cc/J5RS-2MFQ>, accessed January 27, 2022.

<sup>63</sup> “Xi Jinping: Speech at the Symposium of Experts in Economic and Social Fields,” 2-3. The actual formulation that Xi and other Chinese leaders use is “the new pattern of development with domestic great circulation as the mainstay and with mutually reinforcing domestic and international dual circulation.” (以国内大循环为主题、国内国际双循环相互促进的新发展格局). China’s shift to a domestic consumption-driven economic structure—that is, one with “domestic great circulation as the mainstay”—is the key feature of the new pattern of development, not “dual circulation.”

<sup>64</sup> The 14th Five-Year Plan recommends that China achieve “security and controllability” in “critical areas” such as “important industries, infrastructure, strategic resources, and major S&T fields.” The Plan includes sections dedicated specifically to food security, energy security, and financial security. “Outline of the People’s Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035,” 124-127.

<sup>65</sup> Fedasiuk, Weinstein, and Puglisi, “China’s Foreign Technology Wish List,” 29.

<sup>66</sup> Julian Gewirtz, “The Chinese Reassessment of Interdependence,” *China Leadership Monitor*, June 1, 2020, <https://www.prcleader.org/gewirtz>.

<sup>67</sup> Jeffrey Ding and Allan Dafoe, “The Logic of Strategic Assets: From Oil to AI,” *Security Studies* 30, no. 2 (2021), <https://www.tandfonline.com/doi/full/10.1080/09636412.2021.1915583>.