

# South Korea: Caught in the Crosshairs of U.S.–China Competition Over Semiconductors

By Paul Triolo

## Introduction

A number of countries with advanced semiconductor industries are caught in the middle of the growing U.S.-China competition in technology that is focused on advanced computing. While some countries housing the headquarters of key technology companies in the toolmaking sector, including Japan and the Netherlands, have been drawn into the competition previously, but more deeply recently via last year's massive October 7, 2022 export control package unleashed by the U.S. Commerce Department, South Korea and its national champions, Samsung and SK hynix, have arguably incurred some of the most significantly pressure. Those firms have billions of dollars of sunk investment in China-based facilities producing cutting edge memory, and the future of these facilities remains in doubt after a series of new U.S. measures starting with the October Surprise.

South Korean companies are also players in other parts of the global semiconductor supply chain, including semiconductor manufacturing tools, and China remains an important market for both components and electronic devices. Each country caught between the United States and China in the technology cold war faces difficult trade-offs in determining how best to support its leading companies, while navigating changing and often what are viewed as arbitrary decisions coming from Washington that have already significantly disrupted global supply chains. Finally, at the same time as U.S. export controls are having a major impact on the ability of South Korean companies to retain business operations and market access in China, major front end manufacturers, particularly Samsung, are also looking to expand their operations in the United States and benefit from U.S. CHIPS Act funding. All of this puts South Korea in one of the more complex positions as the industry faces continued restructuring, buffeted by both export controls and industrial policies. This paper will explore the dynamics of these twin challenges for both Seoul and South Korean technology players.

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## The U.S.-China Cold War: Focus on Advanced Computing Roils IT Supply Chains

U.S.-China technology competition has been ramping up since the early days of the Trump administration in 2017. The U.S. Trade Representative in August 2017 launched a Section 301 investigation of China's trade practices, kicking off a trade war, and resulting in the imposition of massive tariffs by both sides. Major issues around technology, such as market access, subsidies, and cyber theft of IP were issues originally part of the U.S. investigation, but negotiations to address these tough topics were pushed out to a notional Phase 2 negotiations, which have never materialized. In the meantime, U.S. officials in the Trump administration pushed for expansion of export controls in key sectors where U.S. companies held a strong position, particularly semiconductors. Dozens of Chinese firms were added to the Commerce Department's Entity List—requiring U.S. suppliers to apply for export licenses—during the Trump era.<sup>1</sup> In addition, late in the Trump administration, U.S. officials for the first time deployed major extraterritorial export controls bilaterally, via the foreign direct product rule (FDPR), which initially targeted only Huawei, and required U.S. and other suppliers globally to apply for a license to produce semiconductors on behalf of Huawei.<sup>2</sup>

The extension of extraterritorial controls, immediately expanded the U.S.-China technology competition well beyond the bilateral relationship, ensnaring companies in other jurisdictions in the growing regulatory expansion. Initially the major foundries, TSMC in Taiwan, Samsung and SK hynix in South Korea, which had been suppliers to Huawei were caught in the expanding U.S. export control net. Under the U.S. FDPR rule for Huawei, they could not continue to manufacture semiconductors for Huawei without a license. U.S. licensing policy in the Trump era and early in the Biden administration was fairly permissive for major suppliers of commodity semiconductors – general purpose semiconductors like CPUs and memory, as opposed to specially designed application specific integrated circuits (ASICs) – to Huawei, while TSMC cut off support to Huawei and its chip design arm HiSilicon. TSMC had been manufacturing all of HiSilicon's chip designs for Huawei's four business lines, consumer devices, telecommunications infrastructure, cloud service, and AI.<sup>3</sup>

The Biden administration initially continued most of the policies from the Trump era with respect to semiconductors and Chinese end users. There was some reexamination of licensing policy around Huawei suppliers, and dozens more Chinese firms ended up on the Entity List during the first two years of the Biden administration. But a major inflection point was reached in the Fall of 2022. Two major events – the articulation of a new U.S. policy on technology

controls related to China, and the release of a major new package of export controls – occurred that would result in more U.S. allies and non-U.S. companies, including from South Korea, being dragged into U.S. attempts to draw lines around China’s domestic semiconductor industry capabilities, and limit exports of some advanced chips to Chinese end users.

The policy rationale for U.S. controls on semiconductors and semiconductor manufacturing equipment, as well as other areas of advanced computing, was first articulated in September and October 2022 by U.S. National Security Advisor Jake Sullivan. Sullivan’s formulation came in three distinct but related parts: First, the United States, Sullivan asserted, would no longer seek a sliding scale of advantage over China in certain advanced technologies, but an absolute advantage.<sup>4</sup> Second, Sullivan characterized U.S. policy with respect to China and technology as “small yard, high fence”, an idea that had been kicking around in academia for some time. Proponents of this policy held that the United States should tightly control only a small subset of critical technologies.<sup>5</sup> Third, Sullivan stressed that advanced compute, biotechnology, and green technology, were their pillar technologies that were henceforth of high national security concern to the United States.<sup>6</sup>

Advanced compute included sectors such as high performance computing and supercomputers, artificial intelligence, semiconductors, and semiconductor manufacturing. On October 7, 2022, the Commerce Department dropped a major package of controls (hereafter the October Package) that attempted to control many aspects of advanced compute related to China’s domestic capabilities and ability to purchase advanced semiconductors from global suppliers. It was an unprecedented attempt by one country to essentially freeze the capacity of another country across a number of technology domains that were all part of complex global supply chains, large parts of them centered in Asia. The new controls necessarily meant many other countries would henceforth become embroiled in U.S. efforts to contain China’s technology rise in advanced computing. In addition to Japan and the Netherlands, and by extension Germany, France and some other European countries part of semiconductor manufacturing tool supply chains, in Asia, Japan and South Korea were the other countries whose companies were most impacted by the October Package.

By the time of the October Package then there were three major U.S. policy initiatives and measures that were having a major impact on South Korean semiconductor firms:

- **Multilateral controls** on advanced manufacturing equipment, primarily advanced lithography gear.
- The October Package controls on **end use and domestic persons**.
- **Guardrails** around the August 2022 CHIPS and Sciences Act, restricting a certain level of investment in China-based facilities for companies accepting federal incentives.<sup>7</sup>

Each of these initiatives and its impact on South Korean firms will be examined below.

### **Multilateral Controls on the Most Advanced Lithography Systems Complicates Upgrade Roadmaps**

Even prior to the release of the new U.S. controls, the China-based operations of both Samsung and SK hynix had been significantly impacted by U.S. efforts to control advanced chip making technology. Those facilities, primarily in Wuxi, are key elements of both firm's global operations, and manufacture an appreciable proportion of NAND for Samsung, and DRAM and NAND for SK hynix—estimates put the China-based memory production for each firm at around 40 percent of total global output as of 2022.<sup>8</sup>

The United States, working within the Wassenaar Agreement-- a voluntary export control regime that promotes transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies—had gotten agreement in the 2019 timeframe to restrict the access of China-based companies to advanced lithography equipment from Dutch giant ASML.<sup>9</sup> The U.S. restrictions meant that Chinese foundry companies, including leader SMIC, would not be able to purchase ASML's extreme ultraviolet (EUV) lithography systems, required for making semiconductors at below roughly the 7 nm node.<sup>10</sup> While the primary targets were Chinese domestic foundries, such as leader SMIC, the controls were country-based, which has meant multinational manufacturers with major facilities in China, including Samsung and SK hynix, have also been prevented so far from upgrading their China based operations.

The use of EUV for memory is following a complex roadmap that is very different from logic chips of the type used in advanced smartphones. For logic chips, EUV has been used for some time by TSMC, Samsung, and Intel, to manufacture chips starting at around 7 nm. While existing dense ultraviolet (DUV) lithography systems can be used for some layers of a semiconductor stack at 7 nm, EUV is a much more efficient and ultimately cost effective solution for moving to more advanced nodes.

For memory, the story is different. Here is a more detailed notional roadmap for DRAM and NAND memory companies and the use of EUV systems, which runs to 2028 and shows how extended roadmaps are for advanced technology processes. For example, for EUV, the roadmap is likely to be something like this: 2023-2024: R&D and pilot production of EUV lithography for 1-gamma and 1-delta nodes; 2025-2026: Introduction of EUV lithography for select 1-gamma and 1-delta products; 2027-2028: Widespread adoption of EUV lithography for all DRAM products. For flash NAND, the roadmap will likely look like this (though most of the advances currently are via increased numbers of layers): 2024-2025: R&D and pilot production of EUV lithography for 3D NAND nodes; 2026-2027: Introduction of EUV lithography for select 3D NAND products; 2028-2029: Widespread adoption of EUV lithography for all 3D NAND products.<sup>11</sup>

Major memory leaders, including Samsung, SK hynix, Micron, Western Digital and Kioxia, are all investing in EUV research and systems. For example, Samsung Electronics is already using EUV lithography to manufacture its DRAM chips, and is working with ASML to apply the Dutch firm's next generation high numerical aperture (NA) EUV lithography system for future DRAM production.<sup>12</sup>

The U.S. controls on EUV, however, have had a major impact on the plans for Samsung and SK hynix to continue to upgrade their China-based manufacturing facilities. This is because the Wassenaar controls are country specific, meaning that SK hynix, which has tried to get a license for its Wuxi facility, was not able to get approval because of concerns about its China-based facility.<sup>13</sup> The Wassenaar controls on EUV have been in place for a decade,<sup>14</sup> but it was not until around 2018 that the Dutch government apparently denied a license to SMIC to purchase an EUV system—this decision is still not public, and likely came after SMIC had already obtained an initial contract from ASML to purchase the system. The Wassenaar controls do not include coordination of licensing, and the Dutch government could technically make a decision to issue a license on its own. But U.S. officials reportedly shared classified information with the Dutch government as part of the effort to compel The Hague to deny the license.<sup>15</sup> SK hynix may also have attempted to get a license for its Wuxi facility, but this was also apparently torpedoed by the Dutch government, likely at the behest of the U.S. officials. The issue of SK hynix's ability to procure ASML EUV systems for its China facilities appears to have initially become of high concern to SK hynix leadership in 2021 and was almost certainly a major factor in the July 2021 visit to Washington, DC by SK Hynix Chief Executive Lee Seok-hee, who reportedly raised the issue with U.S. officials.<sup>16</sup>

Critically, the argument that U.S. officials likely made was that despite the EUV system going to a foreign multinational facility in China, and under foreign company control, there was the risk of some diversion of the system, or at a minimum some know-how about how to operate EUV lithography gear. Industry experts are highly skeptical that there would be any fear of diversion of an entire EUV system from a China-based facility operated by a multinational corporation.<sup>17</sup> Such companies as SK hynix and Samsung, maintain tight security around manufacturing systems in general, and around EUV systems in particular, given the high costs and sensitivity around these systems. It remains unclear whether SK hynix actually attempted to purchase an EUV system from ASML, and whether ASML applied for a license to the Dutch government that was rejected due to U.S. government pressure.

### **The October Package: South Korean Firms and Facilities in China among First Collateral Damage**

In any case, even before the much more controversial elements of the October Package impacted the operations of multinationals in China manufacturing memory, the key firms already faced a major disruption of their roadmaps to upgrade China-based facilities with EUV seemingly off the table for China. The October Package added additional complications for the Korean producers in China by including memory in the end use controls that were a critical part of the package. In addition, the new rule included licensing requirements for domestic personnel working at facilities in China where production processes for 16/14 nm for logic, 128 layers for NAND, and 18 nm for DRAM were being deployed.<sup>18</sup> These so-called domestic persons controls were unprecedented, and resulted in all U.S. toolmakers pulling personnel from the facilities they were supporting in China, primarily founder leader SMIC and NAND leader YMTC, and DRAM leader CXMT.

At the same time, US officials appear to have belatedly realized that the controls would also require U.S. and foreign toolmakers to pull service personnel from the Samsung and SK hynix memory facilities, and at the Intel operated facility in Dalian owned by SK hynix that was also a major producer of NAND memory. Over the weekend of October 8, Commerce Department officials scrambled to come up with a solution, eventually issuing a non-public letter that exempted the multinational facilities in China for one year from the domestic persons and other end use controls. Industry officials described a situation where the companies were minutes from having to pull personnel from the Korean facilities and the Dalian fab operated by Intel but owned by SK hynix.<sup>19</sup>

In addition, for many firms part of the semiconductor manufacturing supply chain, particularly tool makers, the inclusion of memory in the October Package came as a major surprise—Commerce officials had apparently not mentioned that memory would be included during previous discussions with industry around the drafting of the new rule.<sup>20</sup> Memory as a commodity, without real legacy node production, was apparently included at the last minute. The justification for including memory remains unclear, but likely centered on an older argument that Chinese memory companies, which have been recipients of major subsidies from the Chinese National IC Investment Fund, had the potential to eventually produce memory at a lower cost than western firms, including some firms that were trusted suppliers to the U.S. government and defense industry.<sup>21</sup> Many industry officials and former U.S. export control officials dispute this reasoning,<sup>22</sup> and at the time of the controls, YMTC held only a very small share of the global NAND market, and was described by some as 4 generations and 8 years behind the cutting edge. It would appear highly unlikely that either YMTC or CXMT posed a threat to the dominance of western firms in either NAND or DRAM at the time of the release of the October Package.

### **CHIPS Guardrails Pose Major Challenge for Foreign Multinationals Manufacturing Chips in China**

Finally, the as part of the so-called “guardrails” around the U.S. CHIPS an Science Act, passed in August 2022, a package that provides \$52 billion in grants and incentives for companies willing to cite front end facilities in the United States at both advanced and mature nodes, along with key companies part of their supply chains, Commerce officials decided to restrict the ability of companies receiving U.S. funds to upgrade and expand any facilities they were operating in China.

The final rule was issued in September 2023. The rule prohibits recipients of CHIPS incentives funds from using the funds to construct, modify, or improve a semiconductor facility outside of the United States; restricts recipients of CHIPS incentives funds from investing in most semiconductor manufacturing in foreign countries of concern for 10 years after the date of award; and limits recipients of CHIPS incentives funds from engaging in certain joint research or technology licensing efforts with a foreign entity of concern that relates to a technology or product that raises national security concerns. Furthermore, if these guardrails are violated, the Department can claw back the entire federal financial assistance award.<sup>23</sup>

The key provisions of most concern to South Korean government officials and companies are the specific requirements for expansion of both “advanced” and “legacy” facilities in “foreign countries of concern,” meaning China. These provisions are as follows:

- **Advanced facilities.** *The final rule ties expanded semiconductor manufacturing capacity to the addition of cleanroom or other physical space and defines material expansion as increasing a facility's production capacity by more than five percent.* This threshold is intended to capture even modest transactions to expand manufacturing capacity but allows funding recipients to maintain their existing facilities through normal course-of-business equipment upgrades and efficiency improvements.
- **Legacy facilities.** The statute places limits on the expansion and new construction of legacy facilities in foreign countries of concern. *The rule provides details regarding this restriction, prohibiting recipients from adding new cleanroom space or production lines that result in expanding a facility's production capacity beyond 10 percent.* The rule establishes a notification process for recipients that have plans to expand legacy chip facilities so the Department can confirm compliance with the national security guardrails.

Prior to the issuance of the final rule, South Korean government officials had sought clarity from the Biden administration on how the guardrails will work, given the significant investments that South Korean giants have in China-based facilities. Earlier in 2023, there were media reports that South Korean officials were pushing for the 10 percent figure. The issue was even raised by South Korean President Yoon Suk Yeol as early as March.<sup>24</sup> The guardrails and other provisions of the CHIPS Act were the subject of numerous meetings between Commerce Department officials and South Korean government officials between March and September. Both Samsung and SK hynix are taking part in CHIPS Act funded projects—Samsung has been expanding facilities in Texas for some time—and are concerned about a number of other “guardrails” around CHIPS Act funding. In late April, for example, Industry Minister Chang-Yang Lee made a request to Raimondo to help resolve the uncertainties around subsidy requirements, such as providing “excessive” corporate information and sharing excess profit with the U.S. government, according to a statement from the South Korean Ministry of Trade, Industry, and Energy.<sup>25</sup>



These concerns are also a result of other actions by the Commerce Department in recent years. For example, in late 2021, the Commerce Department, seeking to better understand supply chain issues in the wake of the global semiconductor shortage, issued a request for information (IFR) to large semiconductor firms, including Samsung and SK hynix. The requests for information in the IFR were deemed sensitive and proprietary by industry players, given sensitive non-disclosure agreements companies sign with their customers. South Korean officials and leading companies are sensitive to this issue also in the CHIPS Act context, where U.S. officials are asking for a lot of data associated with supply chains, technology processes, and customers as part of the applications. The CHIPS Act's broader guardrails also call for some clawing back of "excess profits." without more clearly defining how these would be defined. Companies such as Samsung and SK hynix, in a cyclical business-like memory, almost certainly object to this, because profitability is not determined on a year-to-year basis, for example, but over the lifetime of a particular facility.

As if these three major U.S. policy choices were not complex enough for South Korean firms to navigate, Chinese retaliation against U.S. export controls resulted in a further complication for the Korean majors in the Spring of 2023. In retaliation for the inclusion of memory leader YMTC on the Entity List in December 2022, and the impact of the October Package on YMTC, China launched a cybersecurity probe of U.S. memory leader Micron in March, and then declared that Micron had failed the review, resulting in a ban on Micron products being used by Chinese critical information infrastructure operators (CIIOs).<sup>26</sup> The Cyberspace Administration of China (CAC), which conducted the review, has never clarified the exact scope of CIIOs, but the ban means that many Chinese companies are asking their suppliers for products that do not contain Micron components. As part of the U.S. government response, U.S. officials have apparently discussed the issue with South Korean officials and urged South Korean companies to avoid "backfilling" orders for Chinese customers that no longer wish to use Micron products.<sup>27</sup>

This demand was met with some consternation by South Korean officials and companies. Companies cannot restrict sales to certain customers, and it will be difficult for Samsung and SK hynix to determine whether a particular customer sale actually constitutes "backfilling." Memory products are sold primarily through distributors, making it even more difficult to make such a determination. Memory sales in general are expected to expand during the second half of 2023 and into 2024. As Martin Chorzempa noted in a recent paper: "Therefore, it is not clear how SK hynix or Samsung would know if a new order coming from China was a regular order or a backfill that otherwise would have gone to Micron."<sup>28</sup> Given the cyclical nature of the industry, and the

difficulty of tracking and understanding supply chains and distributors, it is unlikely that the U.S. government will pursue this issue with South Korean companies unless Micron's situation deteriorates rapidly and there is more clear evidence that South Korean firms are benefitting.

### **South Korean Industrial Policy Seeks Expanded Semiconductor Industry but China Issues Will Remain Problematic**

In fact, South Korean officials remain concerned about all the U.S. government measures and policies that have impacted South Korean giants in the semiconductor industry. South Korean officials for example, are concerned that U.S. government officials have not provided sufficiently clear justifications for the inclusion of memory in the October Package.<sup>29</sup> South Korean companies such as Samsung and SK hynix would like to continue operating and upgrading their China-based facilities, which already represent sizeable capex expenditures for the companies, in the 10s of billions of U.S. dollars. In the highly competitive memory business, companies need to upgrade facilities regularly to stay competitive. South Korean officials are also almost certainly concerned about the end use controls part of the October Package. The end use controls for NAND and DRAM, for example, are targeted at production processes that are not the most advanced in the industry, and South Korean officials would like to see more clarity around what types of memory technologies the United States intends to control going forward—hence they believe that the definition of what constitutes advanced memory must be updated.

South Korean officials and others in the industry, in discussions with U.S. officials, have stressed that memory is a commodity product, and that the type of memory they are producing in China is not typically used for supporting military end uses and is hard to tie directly to other areas like human rights abuses. In addition, they would argue that South Korean companies have heavy controls to protect technology being used in China. South Korean officials also argue that the presence of South Korean companies in China is a positive, as Korean companies need to be in China to understand how Chinese competitors are developing technology, and enable Korean firms to better keep ahead of Chinese competitors.

In October 2023, the Biden administration finally determined a way for extending the one-year exemptions granted to South Korean multinationals in October 2022. On October 17, the Commerce Bureau of Industry and Security issued a notice that the China subsidiaries of Samsung and SK hynix would be added to the Verified End User (VEU) list. Designated VEUs located in eligible destinations to which eligible items may be exported, reexported, or transferred (in-country) under a general authorization instead of a license. Here, the new language for

the VEU for these firms noted that all items were ok to ship to these locations “except EUV equipment.”<sup>30</sup> The measure was significant, in that it extends indefinitely, but subject to review, the exemption from parts of the October Package by allowing U.S. and other toolmakers to ship to Samsung and SK hynix China-based facilities without having to get a license. It also allows personnel from toolmakers to remain at these facilities, even though they may be working at or above the end use nodes specified in the October Package.

Despite the Commerce Department action that provides breathing room for Samsung and SK hynix operations in China, it remains unclear whether South Korea would support attempts to set up new multilateral regimes to control dual-use technology, such as semiconductors and manufacturing equipment. In the wake of the dysfunction in the Wassenaar Agreement, with Russian participation meaning the group is not meeting and cannot easily make new decisions, some have called for some the establishment of new multilateral mechanism to broader export control discussions around advanced technologies that have broad civilian uses such as semiconductors, manufacturing equipment, and AI. Many other countries, including the Netherlands and Japan, along with the EU, are likely reluctant to sign up for a new organization targeting dual-use technologies that would be quickly seen as anti-China, and it would be very difficult to get agreement among the key players on which technologies merit control for national security justifications.

The future role of South Korean companies in the China market will remain complex, and a function of a number of different considerations, both at the corporate level, and within the South Korean government. On the one hand, the South Korean government has its own industrial policy initiatives, similar to the CHIPS Act, that will provide major subsidies for leading technology firms, including Samsung and SK hynix. On the other hand, Seoul almost certainly sees U.S. controls that impact Samsung and SK hynix revenue in China and more broadly as working against the ability of those companies to invest more in South Korea based facilities, as well as new facilities in the United States under the CHIPS Act. Given this, South Korean government officials could at some point decide to lobby the Biden administration and subsequent administrations to consider reversing the restrictions on EUV equipment for the China-based facilities of Samsung and SK hynix to enable them to continue upgrading and operating these facilities to keep them competitive.

In this process, SK hynix has also played a role more broadly in the memory sector, as a shareholder in a consortium of companies that hold ownership in Japanese memory major Kioxia, through a complex financial structure overseen

by investor Bain Capital. In October 2023, a deal that would have seen Kioxia merge with U.S. memory giant Western Digital was blocked, at least temporarily, by SK hynix management. While the U.S. and Japanese government were very supportive of the deal, seeing it as a major benefit to growing U.S.-Japanese collaboration in the semiconductor sector, SK hynix management apparently opposed the deal to protect its investment, and was also concerned that the merger would create the top NAND company globally, with Samsung second, and SK a more distant third. The role of the South Korean government in this process remains unclear, as Seoul likely favors some type of three-way collaboration with Tokyo and Washington in the semiconductor sector, as part of broader “friend shoring” efforts, and allowing one of its major semiconductor companies to block a deal favored by Tokyo and Washington did not appear to be going down well in those two capitals.

An additional complication is how the South Korean government will assist its leading companies to continue to expand and dominate these key sectors, particularly should the Western Digital-Kioxia merger eventually occur. Over the past year, Seoul has rolled out the K Chips Act<sup>31</sup> which would provide major tax breaks to companies, and looks to particularly, or primarily, benefit Samsung and SK hynix. The legislation increases the tax credit to 15% from the current 8% for major companies investing in manufacturing facilities – smaller and medium-size firms could see a tax break of up to 25% from 16% now. The qualifications for access to tax breaks would appear to favor large players pursuing advanced node production, and so are likely to primarily benefit Samsung and SK hynix. It seems likely that these incentives and the uncertainty about China-based facilities will encourage greater investment in Korea-based facilities than would have otherwise been the case. However, from a diversity of supply chain point of view, concentrating even more memory production in South Korea, along the border with North Korea, may have other national security implications for both the United States and South Korea, and for the industry as a whole. One key issue is whether these new incentives will help to offset what will be substantial losses eventually in China if both memory giants have to write off existing facilities over the next five years.

### **Conclusion: Uncertainty Will Continue to Cloud the Future**

The memory sector is likely to continue to be contentious when it comes to export controls. At the same time, memory products remain a critical issue for Chinese electronic device makers, as the U.S. controls mean that neither YMTC or CXMT or other Chinese memory firms can supply advanced memory for applications like cutting-edge smartphones. In September, leading Chinese

telecom firm Huawei released several new smartphones and tablets based on the Kirin 9000s. Hardware teardowns of the phone revealed that some of the NAND and DRAM used in the phone came from SK hynix, and the firm has launched an investigation of how SK hynix memory ended up in the Huawei device.<sup>32</sup> It appears that the memory in question was stockpiled by Huawei, sometime in the 2020 period, and SK hynix has insisted that it has complied with U.S. export controls, meaning it would not have been able to ship to Huawei after September 2020. It is possible that Huawei obtained DRAM and NANA via distributors after this date, without the knowledge of SK hynix.

This episode illustrates that particularly with the new restrictions around U.S. DRAM leader Micron, South Korean memory providers will continue to be very important for Chinese device makers, including both those on the Entity List not subject to the FDPR, and those that remain off the list. However, even though the extension of Verified End User status to Samsung and SK hynix has relieved some of the near-term uncertainty around the future disposition of the firms' China-based facilities, as noted above, there remains considerable uncertainty about the future status of these manufacturing operations.

In addition, for two of South Korea's leading firms, the future mix of investments and operations in South Korea, the United States, and China will add major complications to their long-term roadmaps for developing and remaining competitive that were not on the drawing board only four years ago. In addition to the companies' China facility wind down problem, both must contend with the challenges of developing viable commercial support ecosystems and supply chains in the United States. In addition to the above mentioned concerns of South Korean government officials and the companies around information disclosure and profit sharing related to CHIPS Act subsidies, both companies also face labor and workforce challenges, along with cultural issues associated with building a larger presence in the U.S. market. Like the challenges TSMC has faced in Arizona, Samsung will also face issues related to local contractors' lack of experience in constructing and maintaining facilities and systems associated with cutting edge manufacturing facilities, and the lack of economies of scale in terms of technical support and suppliers that they have developed at large complexes in their home countries.

Given the inability to put together a long-term technology or commercial roadmap for Wuxi, Xi'an, and Dalian, South Korea firms cannot conduct normal upgrade schedules, and a certain point will have to decide whether to abandon or sell the facilities in China. This will come at a considerable cost, and the uncertainty of finding a buyer who would be both willing and able to buy facilities

in China operating under major constraints. Chinese firms would by definition not be able to buy facilities operating above the end use controls of the October 7 package, for example. There are few other potential buyers of high-end manufacturing facilities that require considerable maintenance to operate and marketing acumen to make successful. It seems likely that the U.S. and South Korean governments could at some point work out a compensation plan for SK hynix and Samsung, given the high costs and the unprecedented situation where U.S. government policy essentially dictates when a company would need to abandon a multi-billion long-term investment. The decisions of the Biden team thus will long outlive the current administration and continue to create headaches for U.S.-South Korean relations well into the end of the decade.

## Endnotes

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