

The Impact of US Export Controls on Korean Semiconductor Exports

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Background: Transformation of the Global Trade Paradigm

- **From free trade to protectionism**

- Protectionism driven by competition over technological hegemony, particularly between the US and China
- Technologies (AI, quantum computing) and industries (semiconductors, batteries, biotechnology)

- **Government intervention and regulation**

- More government involvement in global trade and strategic investment
- Policies aimed at promoting domestic advancements, mitigating foreign dependencies, and inhibiting the capacity-building efforts of rival nations

- **Global impact**

- Both major players (US and China) and other global economies significantly influenced

Research Goals

- **Question: How have US export controls impacted other countries?**
 - **(Key challenge)** How to empirically account for the effects of trade control measures
- **Case study: South Korean semiconductors**
 - Exports from South Korea represented approximately 25% of global memory semiconductor exports in 2022
 - 72% of South Korea's memory semiconductors went to China and Hong Kong
- **Methodology**
 - **(Granular, product-level analysis)** Utilized detailed 10-digit product-level data
 - **(Detailed semiconductor product categorization)** Eight industry-relevant subcategories (matching HS)
 - **(Refined identification of export-controlled items)** Reviews the documents to list ECCNs

Main Findings

- **Export decline Post-October 2022**

- After October 2022, the value of semiconductor exports from South Korea to China (including Hong Kong) decreased by 13.7%
- No significant changes following the 2020 and 2023 export controls

- **Sector-specific declines**

- Memory (31.9%), discrete components (25.8%) and discrete component parts (42.7%) exports all plunged after the October 2022 round of export controls

- **Reduction in unit prices**

- Memory semiconductor unit prices declined by 10.3% after 2020 measures
- A further decline of 34.6% was observed following the 2022 measures

US export controls have significantly impacted South Korea's semiconductor exports, particularly in the high-tech memory sector

Related Literature

- **Empirical studies on the trade effects of US export regulations**
 - Few studies have focused on the trade effects of US export controls (Ando et al., 2023, Hayakawa et al., 2023).
 - Hayakawa (2024) also found that the October 2022 round of export controls resulted in lower exports of semiconductor IC products and equipment (IME) from the US to China.
- **Broader economic ramifications of export controls**
 - Beyond trade impacts, studies have found that export controls have extensive economic effects (Jones and Karreth, 2010).
 - Simulations in Cerdeiro et al. (2021) and Funke and Wende (2022) predict GDP declines in the US and China and global market disruptions due to US export controls.
- **South Korean controls as case studies**
 - Handful of studies have examined the impact of South Korea's export control regime.
 - Positive outcomes include increased imports, bolstered national security, and market stability (Jang and Song, 2021), and productivity gains (Moon and Jang, 2023).

[Today's Talk]

- **Part 1. Data**
- **Part 2. Empirical Results**
- **Part 3. Conclusion**
- **Part 4. Future Research and Teaching Plans**

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Three Instances of Strengthened US Export Controls on China

- **Clamping down on exports of critical technologies to China**

- Mechanism: Amendments to the Foreign Direct Product Rule (FDPR) and the Export Administration Regulations (EAR)



Aug. 2020: Huawei FDPR

- The Huawei FDPR extended US regulatory controls over technology outside the US and mandated licensing for Huawei-related transactions.

Oct. 2022: New FDPR rules for supercomputer and manufacturing equipment

- Certain semiconductor products (e.g. advanced computing chips, supercomputer components), and semiconductor manufacturing equipment were added to the control list.

Oct. 2023: Further tightening of export restrictions imposed on China

- Amendments were made to expand export controls on semiconductors and related manufacturing equipment, aiming to address circumvention risks

Semiconductor Industry Sectoral Classifications

- **Classifying the semiconductor industry with HS codes**

- We define the semiconductor industry based on KHS Codes, following Kim and Shim (2022)
- We divide the semiconductor industry into eight segments:

- (1) Memory semiconductors,
- (2) System semiconductors (non-memory),
- (3) Parts for integrated circuits
- (4) Transistors
- (5) Diodes
- (6) Other discrete components
- (7) Parts for discrete components
- (8) Silicon wafers

- **Some deleted codes have been reclassified according to 2024 HS standards**

- Revised codes were deleted during HS code revision; underlined HS codes in the table
- These codes are reclassified in 2024 HS based on their original names

Semiconductor Industry Sectoral Classifications

Category	Sub-category (MTI 6-digit)	HS 10-digits (KHS)
Memory Semiconductors	Memory semiconductors (831110)	8473304060, 8542321010, 8542321020 8542321030, 8542321090, 8542322000, 8542323000
System semiconductors (non-memory)	System semiconductors (Processors/Controllers) (831120)	<u>8542311000</u> , 8542312000, 8542313000
	Analog semiconductors (831130)	8542331000, 8542332000, 8542333000
	Other integrated circuit semiconductors (831190)	8523521000, 8542391000, 8542392000, 8542393000
Integrated circuit parts	Integrated circuit parts (831200)	<u>8542900000</u> , 8543901000, <u>8548001000</u>
Transistors	Transistors (831310)	8541211000, 8541219000
Diodes	Diodes (831320)	8541101000, 8541109000, <u>8541599000</u> , <u>8541511000</u> <u>8541512000</u> , <u>8541513000</u> , <u>8541514000</u>
Other discrete components	Other discrete semiconductors (831390)	8541301000, 8541302000, 8541303000, 8541304000, <u>8541491000</u> , <u>8541411000</u> , <u>8541419000</u> , <u>8541492000</u> , <u>8541409021</u> , <u>8541409022</u> , <u>8541409029</u> , <u>8541420000</u> , <u>8541430000</u> , <u>8541493000</u> , <u>8541499000</u> , 8541601000, 8541609000
Discrete component parts	Discrete semiconductor parts (831400)	<u>8534002000</u> , 8541903000, 8541909000
Silicon wafers	Silicon wafers (831500)	3818001000, <u>3818002010</u> , <u>3818002090</u>

Note: The semiconductor industry classification is based on the HS Codes by Kim and Shim (2022). Some deleted codes have been reclassified according to 2024 HS standards (underlined HS codes).

Source: Korea Electronics and Telecommunications Industry Promotion Institute. Re-cited from Kim and Shim (2022) in the HS & MTI Code Linkage of the Electronic Export-Import Statistics System.

Export Control Classification Number (ECCN)

● Export Control Classification Number (ECCN)

- ECCNs are five character alpha-numeric designations used to identify dual-use items for export control.
- An ECCN categorizes items based on the nature of the product and its respective technical parameters (i.e. type of commodity, software, or technology)

Commerce Control List Categories

0	Nuclear materials, facilities and equipment (and miscellaneous items)
1	Materials, chemicals, microorganisms, and toxins
2	Materials processing
3	Electronics
4	Computers
5	Part 1 -- Telecommunications and Part 2 -- Information security
6	Sensors and lasers
7	Navigation and avionics
8	Marine
9	Aerospace and propulsion

Five Product Groups

A	End items, equipment, accessories, attachments, parts, components, and systems
B	Testing, inspection, and production equipment
C	Materials
D	Software
E	Technology

Electronics

End items, equipment, accessories, attachments, parts, components, and systems

ex) **3A001** items:

ECCN	Description
3A001.a	Integrated circuits, general purpose
3A001.a.11	Integrated circuits, compound semiconductor
3A001.b.4	Amplifiers, microwave solid state
...	...

Source: Bureau of Industry and Security (BIS).

Matching ECCN-KHS

● ECCN and the HS

- The Strategic Goods Management System (Yestrade) provides ECCN and HS code linkage information
- Data for study were built by linking KHS codes with ECCN numbers subject to enhanced US controls

전략물자(이중용도)

☛ > 알림/정보마당 > 전략물자(이중용도)

· 게시물 검색 3A001

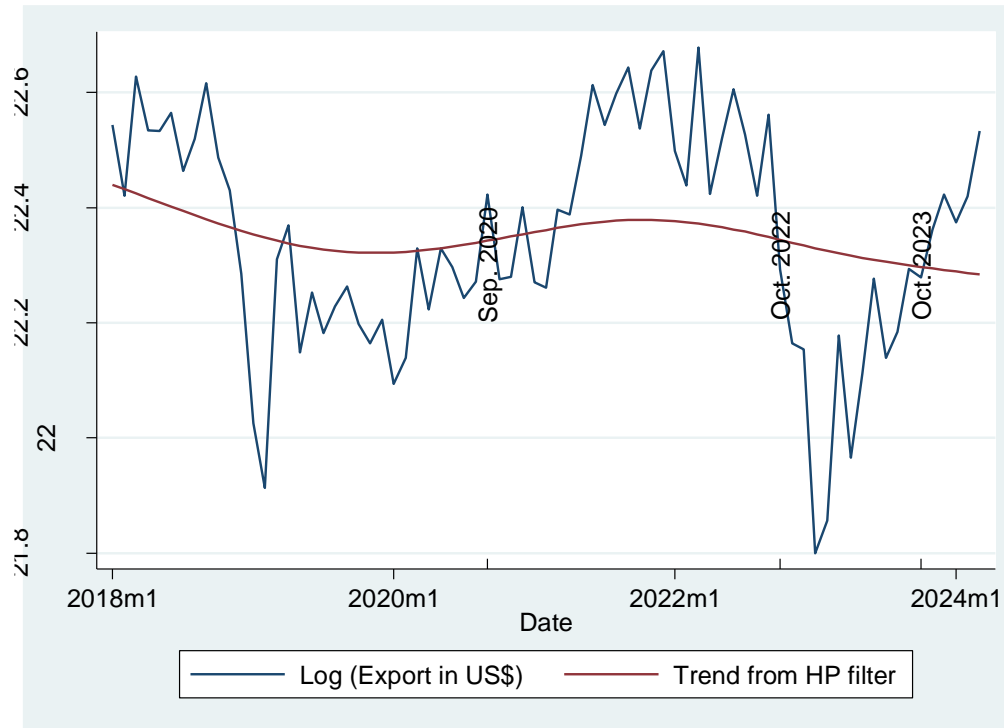
※ 본 정보는 HSK 연계표 정보로써 전략물자 해당 가능성이 높은 HS 번호의 품목군과 관련 통제번호의 정보를 제공하는 것임에 유의하시기 바랍니다.

☞ 총 313 개 / 현재페이지: [1/32]

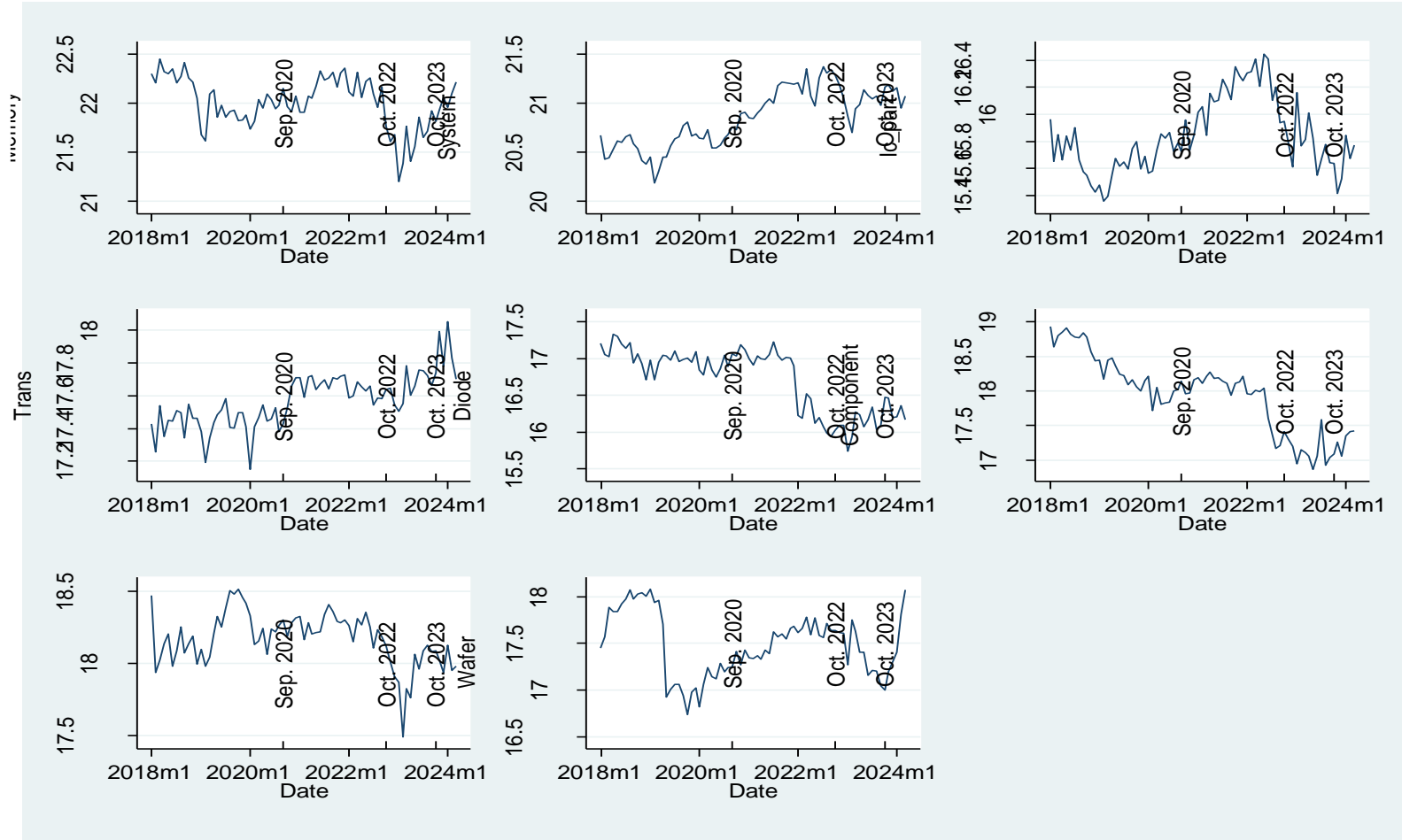
품목분류(HS)	HSK품목명	HSK영문명	통제번호
8525609000	기타	Other	3A001.b.12.
8542311000	모노리식(monolithic) 집적회로	Monolithic integrated circuits	3A001.a.5.a.4.
8542391000	모노리식(monolithic) 집적회로	Monolithic integrated circuits	3A001.a.7.b.
8541491000	칩, 다이스와 절단되지 않은 웨이퍼	Chips, dice and wafers not yet cut into chips	3A001.a.6.
8542311000	모노리식(monolithic) 집적회로	Monolithic integrated circuits	3A001.a.3.
8541909000	기타	Other	3A001.h.
8542312000	하이브리드 집적회로	Hybrid integrated circuits	3A001.a.2.
8542393000	복합구조칩 집적회로	Multichip integrated circuits	3A001.a.
8501311090	기타	Other	3A001.e.
8542311000	모노리식(monolithic) 집적회로	Monolithic integrated circuits	3A001.a.2.

Source: <https://www.yestrade.go.kr/>

Basic Trends in Semiconducts using HP Filters (Total Semiconductors)



Exports (Subsegments)



[Today's Talk]

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Estimation Equation

- Estimate the following gravity equation following Hayakawa (2024)

$$y_{jpt} = \beta_0 + \beta_1 \cdot I_{Semi., Sep 2020}^{China} + \beta_1 \cdot I_{Semi., Oct 2023}^{China} + \beta_1 \cdot I_{Semi., Oct 2023}^{China} + \eta_{jp} + \eta_{jt} + \eta_{pt} + \varepsilon_{jpt}$$

- y_{jpt} : 1) Export, 2) Unit price, 3) Quantity of product (p) to country (j) at time (t)
 - $I_{Semi., Sep 2020}^{China}$: Dummy variable 1 if semiconductor product to China or Hong after Sep. 2020
 - $I_{Semi., Oct 2022}^{China}$: Dummy variable 1 if semiconductor product to China or Hong after Oct. 2022
 - $I_{Semi., Oct 2023}^{China}$: Dummy variable 1 if semiconductor product to China or Hong after Oct. 2023
 - η : fixed effects
-
- Data
 - 10-digit monthly exports from January 2018 to March 2024

Result: Impact on Exports

- After October 2022 round of US controls, South Korean exports of targeted semiconductor products to China (including Hong Kong) fell. The results are statistically significant.

VARIABLES	Log (Export)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Semi. All	Memory	System	IC Parts	Transistor	Diode	Other Discrete Components	Discrete Component Parts	Silicon Wafer
After Sep. 2020	0.030	0.286***	0.039	-1.460	[0.086]	0.149	0.014	-0.199**	0.046
	[0.041]	[0.083]	[0.081]	[0.959]	-0.142	[0.224]	[0.103]	[0.102]	[0.239]
After Oct. 2022	-0.147***	-0.385***	0.159	0.517	[0.116]	-0.207	-0.258***	-0.427***	-0.226
	[0.049]	[0.099]	[0.107]	[0.619]	-0.010	[0.236]	[0.091]	[0.120]	[0.235]
After Oct. 2023	-0.010	-0.011	-0.155	-0.785	[0.238]	0.442	0.327**	-0.458	0.068
	[0.106]	[0.225]	[0.256]	[0.574]	-0.120	[0.372]	[0.159]	[0.303]	[0.351]
Constant	9.312***	9.312***	9.312***	9.312***	9.312***	9.312***	9.312***	9.312***	9.312***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Country-Product Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product-Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,391,376	6,391,376	6,391,376	6,391,376	6,391,376	6,391,376	6,391,376	6,391,376	6,391,376
R-squared	0.783	0.783	0.783	0.783	0.783	0.783	0.783	0.783	0.783
Robust standard errors in brackets									
*** p<0.01, ** p<0.05, * p<0.1									

Result: Impact on Unit Prices

- Following the 2020 measures, memory semiconductor unit prices fell by 10.3 percent. After the 2022 measures, they fell by 34.6 percent. The results are statistically significant.

VARIABLES	Log (Unit Price)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Semi. All	Memory	System	Transistor	Diode	Other Discrete Components
After Sep. 2020	0.047	-0.109*	0.062	0.232***	0.169	0.032
	[0.046]	[0.060]	[0.078]	[0.088]	[0.334]	[0.134]
After Oct. 2022	0.009	-0.425***	0.046	-0.003	1.233**	0.107
	[0.056]	[0.071]	[0.090]	[0.155]	[0.489]	[0.116]
After Oct. 2023	0.080	0.081	-0.105	0.336	0.632	0.100
	[0.100]	[0.134]	[0.164]	[0.287]	[0.581]	[0.186]
Constant	4.188***	4.188***	4.188***	4.188***	4.188***	4.188***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Country-Product Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Country-Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Product-Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,386,336	2,386,336	2,386,336	2,386,336	2,386,336	2,386,336
R-squared	0.867	0.867	0.867	0.867	0.867	0.867
Robust standard errors in brackets						
*** p<0.01, ** p<0.05, * p<0.1						

Result: Comparison without ECCNs

- Results vary based on whether ECCNs are taken into account.

	Estimated Coefficients	
	W/ECCNs	W/O ECCNs
Semiconductor All (After Sep. 2020)	0.030	0.051
Semiconductor All (After Oct. 2022)	-0.147***	-0.167***
Semiconductor All (After Oct. 2023)	-0.010	-0.093
Memory (After Sep. 2020)	0.286***	0.168**
Memory (After Oct. 2022)	-0.385***	-0.287***
Memory (After Oct. 2023)	-0.011	0.059
System (After Sep. 2020)	0.039	0.039
System (After Oct. 2022)	0.159	0.159
System (After Oct. 2023)	-0.155	-0.155
IC Parts (After Sep. 2020)	-1.460	-0.366**
IC Parts (After Oct. 2022)	0.517	-0.105
IC Parts (After Oct. 2023)	-0.785	-0.549***
Transistor (After Sep. 2020)	-0.120	-0.120
Transistor (After Oct. 2022)	-0.142	-0.142
Transistor (After Oct. 2023)	-0.010	-0.010
Diode (After Sep. 2020)	0.149	-0.053
Diode (After Oct. 2022)	-0.207	0.067
Diode (After Oct. 2023)	0.442	-0.319
Other Discrete Components (After Sep. 2020)	0.014	0.263***
Other Discrete Components (After Oct. 2022)	-0.258***	-0.379***
Other Discrete Components (After Oct. 2023)	0.327**	0.066
Discrete Component Parts (After Sep. 2020)	-0.199**	-0.199**
Discrete Component Parts (After Oct. 2022)	-0.427***	-0.427***
Discrete Component Parts (After Oct. 2023)	-0.458	-0.458
Silicon Wafer (After Sep. 2020)	0.046	0.074
Silicon Wafer (After Oct. 2022)	-0.226	-0.601**
Silicon Wafer (After Oct. 2023)	[0.351]	0.350

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Conclusion

- **Empirical analysis: Impact of US export controls on Korea**

- We analyzed the decline in Korean semiconductor exports to China after three separate rounds of enhanced US export controls.
- Detailed 10-digit HS data reveals a significant drop in exports of memory chips, integrated circuits, and related components after the announcement of the October 2022 controls.
- We observed a notable decrease in unit prices of memory chip exports, indicating a substantial impact on high-tech items.

- **Limitations**

- Approach does not sufficiently differentiate items within high-tech sectors on the ECCN list.
- Future studies should aim to improve the accuracy with which controlled items and trade data are linked.

- **Need for further empirical and theoretical exploration**

- Future research should focus on corporate relocations, interconnections within the industry, and the broader impact of export controls.
- Comprehensive understanding of these factors is necessary to fully grasp changes in global trade dynamics.

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Thank you

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