Battle for Chips:

Semiconductors Crucial Role in AI Development and its Implications for U.S.-China Strategic Competition

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Section Reader: Professor Sorelle

Table of Contents

Research Question

What role do U.S. semiconductor companies play in developing U.S. and Chinese AI capabilities and what are the implications for U.S. national security?

U.S. Decoupling Hypothesis

State of Innovation Hypothesis

Table of Contents

Why does AI matter?

Military

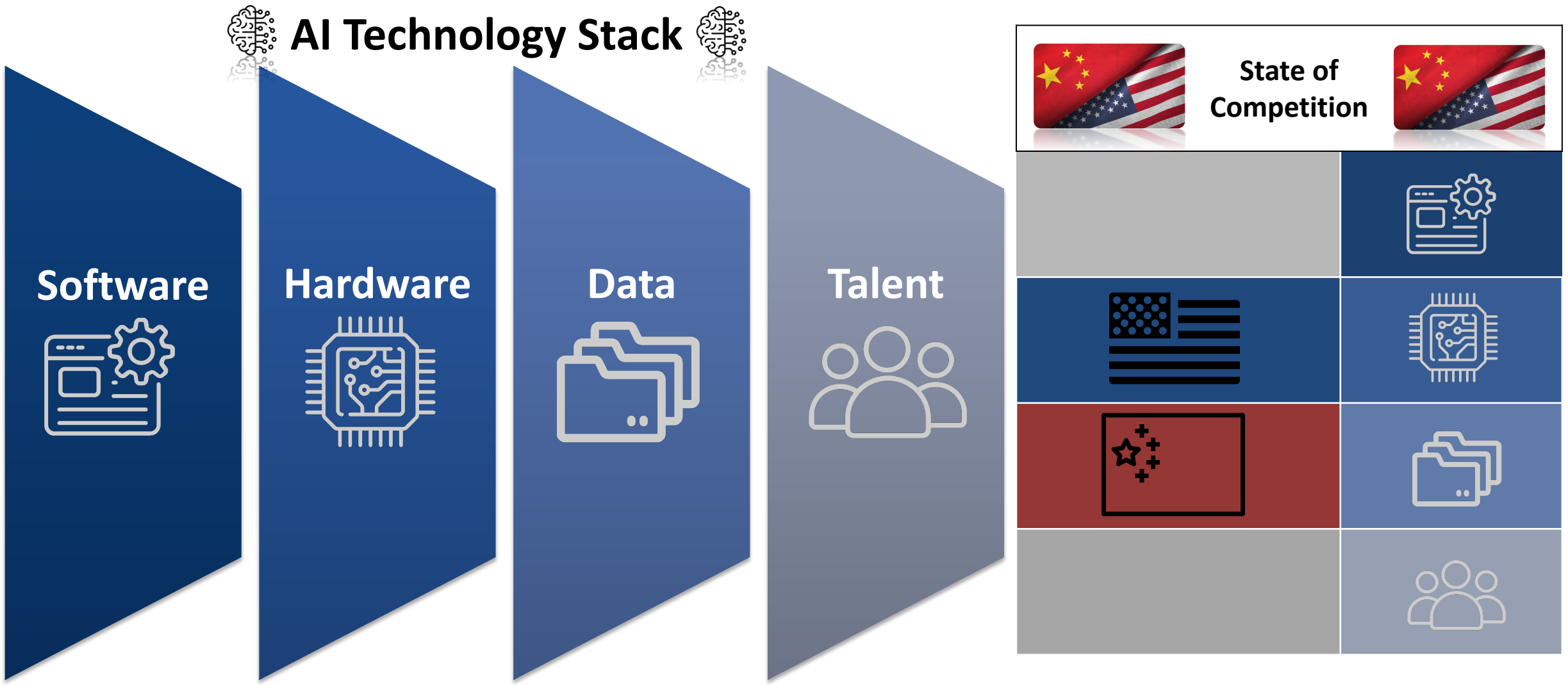
Intelligentized Warfare

Surveillance

Digital Authoritarianism

Sources: NSCAI Report and Expert Interviews

4 parts of the technology stack that lead to robust AI development

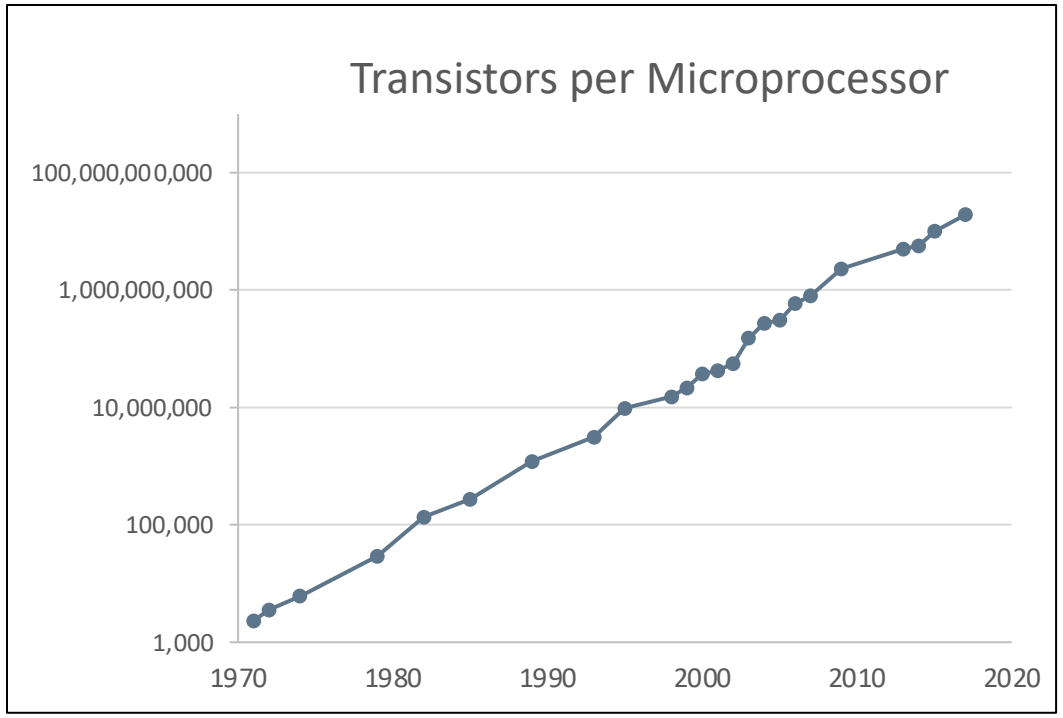


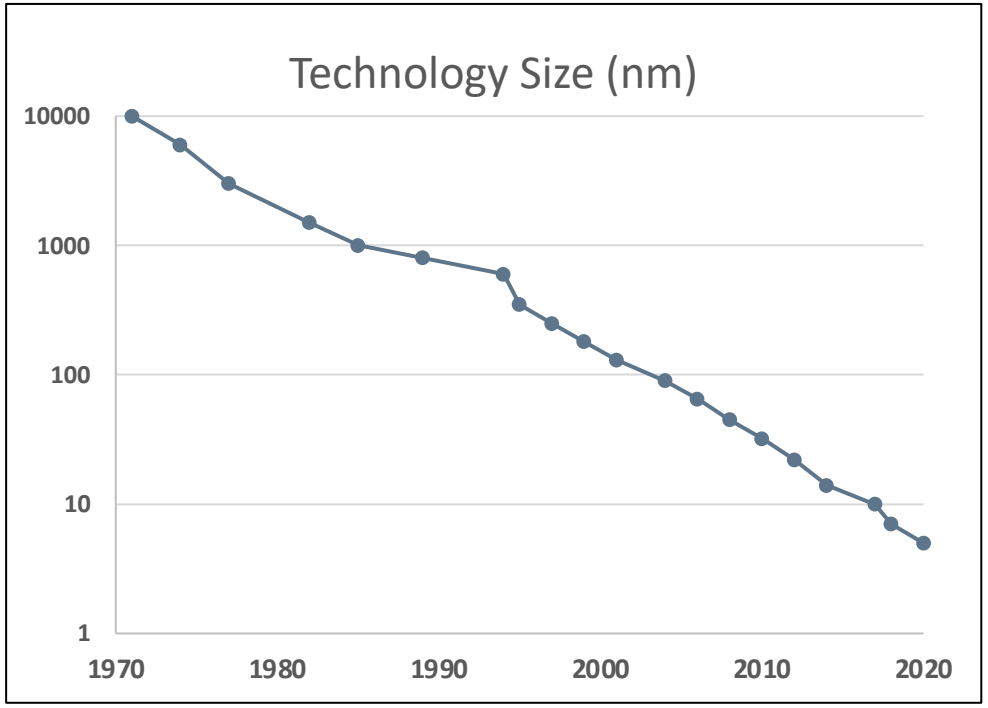
Sources: NSCAI Report

Moore's Law & the 'basis of innovation' for AI development

Semiconductor innovations over the past 20 years have dramatically increased the computing power and use cases of AI

Moore's Law: The *number of transistors on microchips will double every two years.*





Smaller nm node length = more advanced chip

Implications of Moore's Law

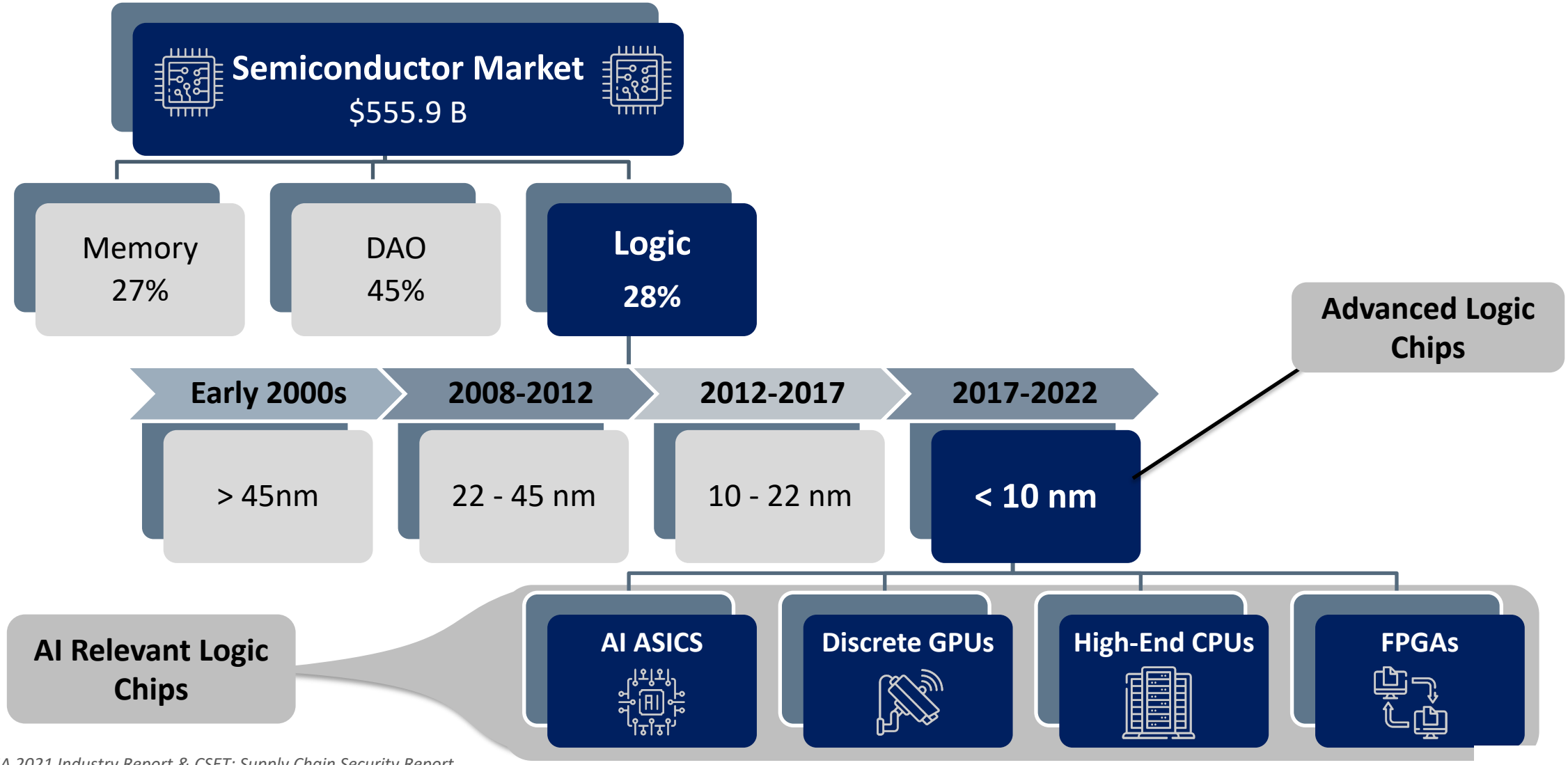
Size & Weight

Power Efficiency

Lower Costs

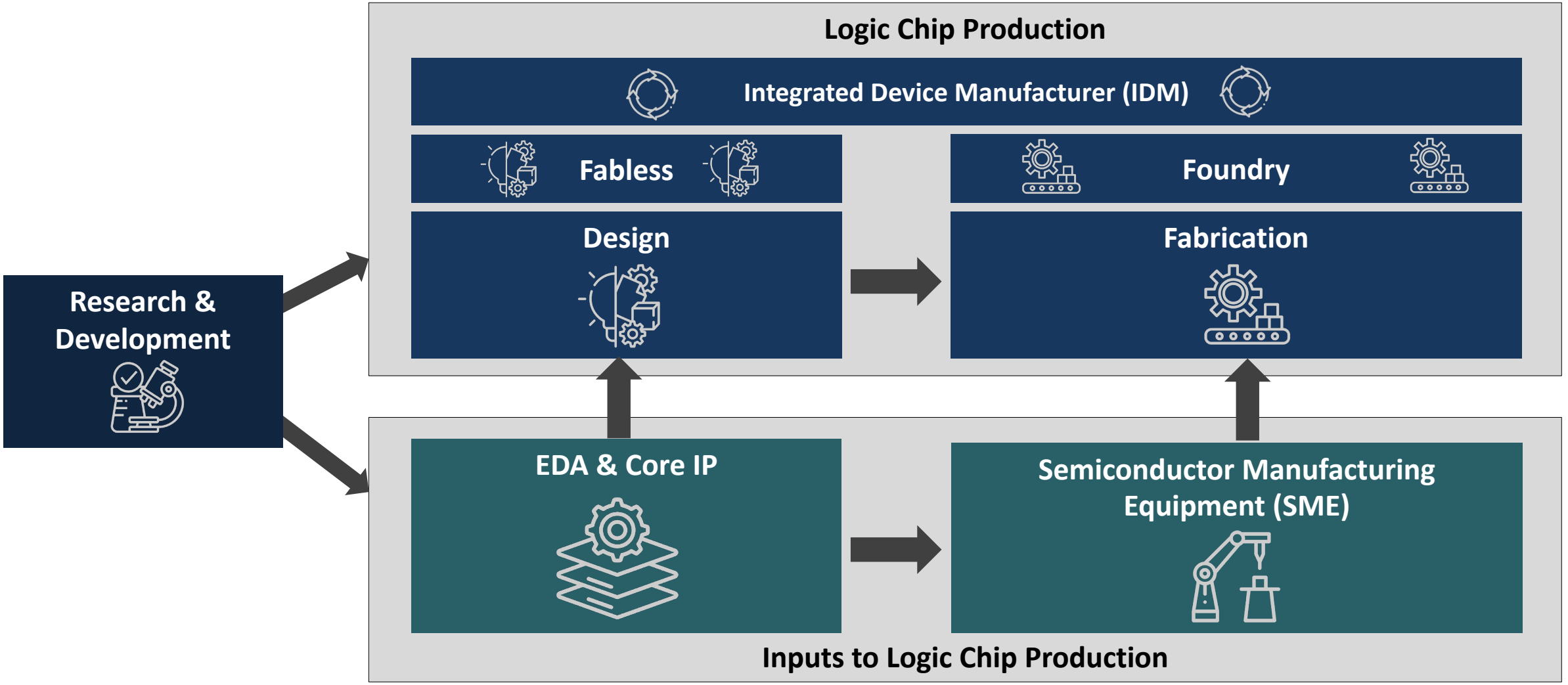
Sources: CSET & Our World in Data

Logic chips are hard to manufacture & key for AI development



Sources: SIA 2021 Industry Report & CSET: Supply Chain Security Report

Overview of the manufacturing process & key chokepoints



Sources: CSET Supply Chain Security Brief

Table of Contents

Qualitative & Quantitative Methods

Expert interviews & data analysis from numerous different databases

Qualitative Sources

Academic Sources	SIA Semiconductor Industry Association; WSJ; RAND Corporation; Center for a New American Security; Council on Foreign Relations; Tufts University
Industry Sources	DELL Technologies; intel
Government Sources	DARPA; National Security Commission on Artificial Intelligence

Quantitative Sources

Bloomberg	Supply Chain Data
Wind	Revenue Exposure to China
PitchBook	Innovation Metric: Number of Start-Ups
U.S. Securities and Exchange Commission	10-K Annual Filings
WSTS World Semiconductor Trade Statistics	Logic Chip Data

Table of Contents

Two Cascading Hypotheses

Decoupling & State of Innovation Hypothesis

Decoupling Hypothesis

Partial Decoupling: As the U.S. government restrict China's access to specific advanced logic chips, it will lead to an inadvertent partial decoupling.

Security

Globalized Business

State of Innovation Hypothesis

Hampering Semiconductor Innovation

Biden Administration's recent export bans reinforce my hypothesis

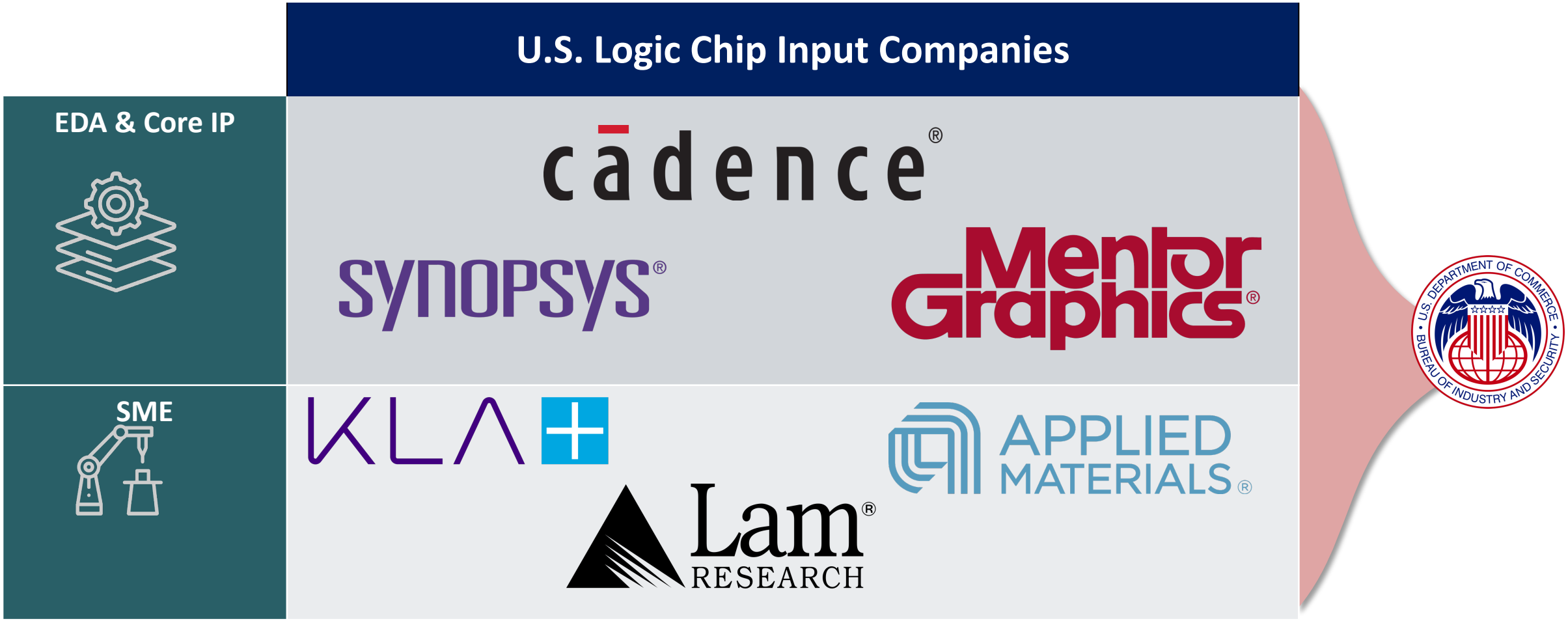
	Advanced Logic Chip Relevant Companies			
	High End CPUs	**FPGAs**	**Discrete GPUs**	**AI ASICs**
Fabless	intel, AMD	XILINX, Achronix Data Acceleration, flexlogix Technologies, Inc., LATTICE SEMICONDUCTOR	AMD, NVIDIA	intel, Google, cerebras, TESLA
Foundry	GlobalFoundries™			
IDM	intel	MICROCHIP		

Sources:

Export bans have targeted the input side of the supply chain

These inputs represent a supply chain chokepoint for China, but the U.S. does not have a monopoly on them

Advanced Logic Chip Input Producers



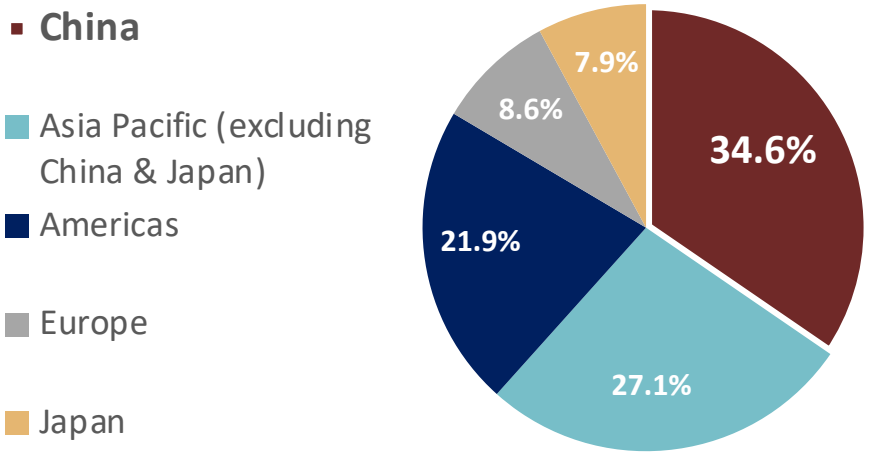
Sources: Expert Interviews & CSET Supply Chain Security Brief

U.S. strategy is to control & restrict the top of the value chain

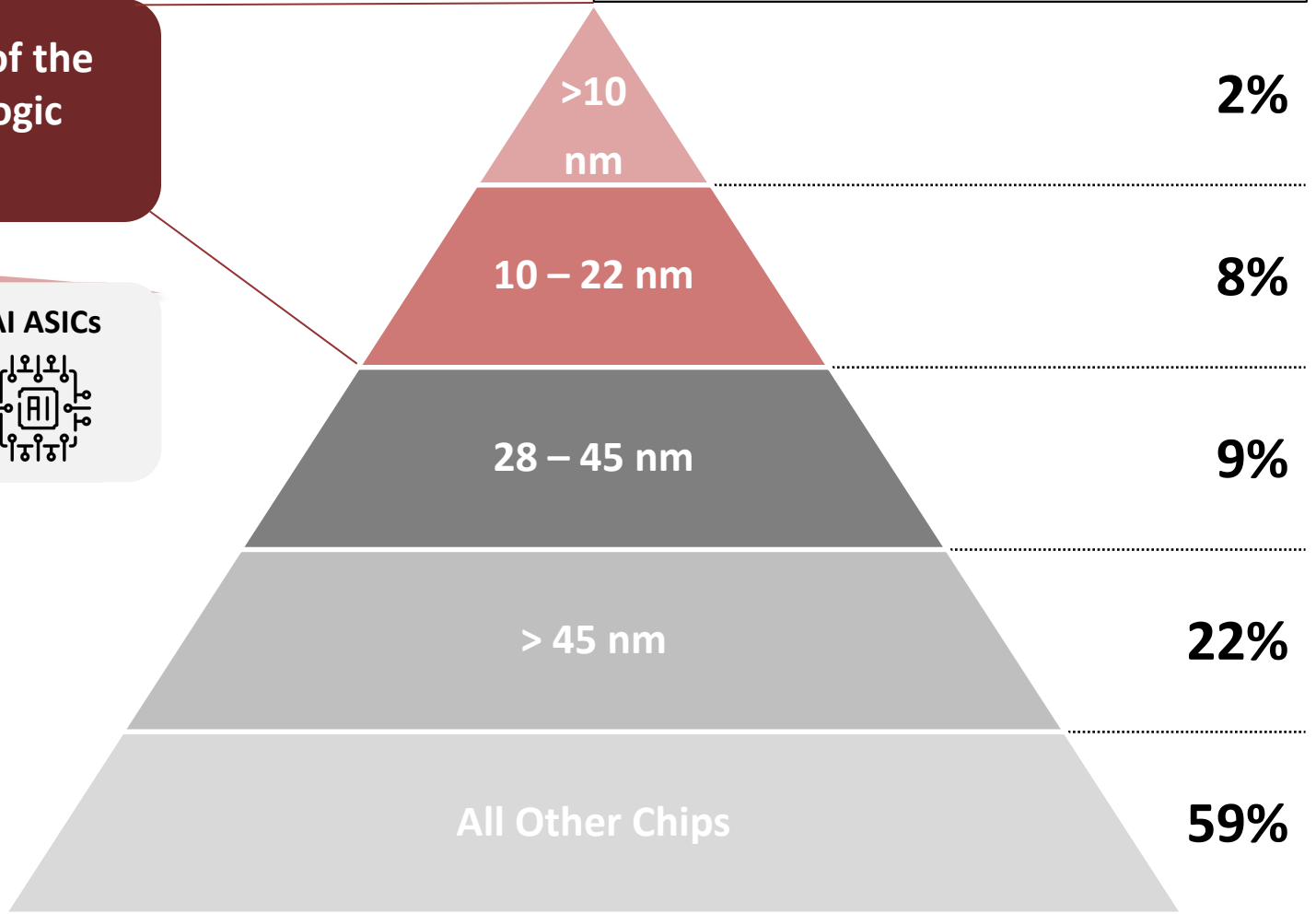
U.S. wants to control the top of the value chain where advanced logic chips rest

- High-End CPUs
- Discrete GPUs
- FPGAs
- AI ASICs

SEMICONDUCTOR GLOBAL SALES 2021

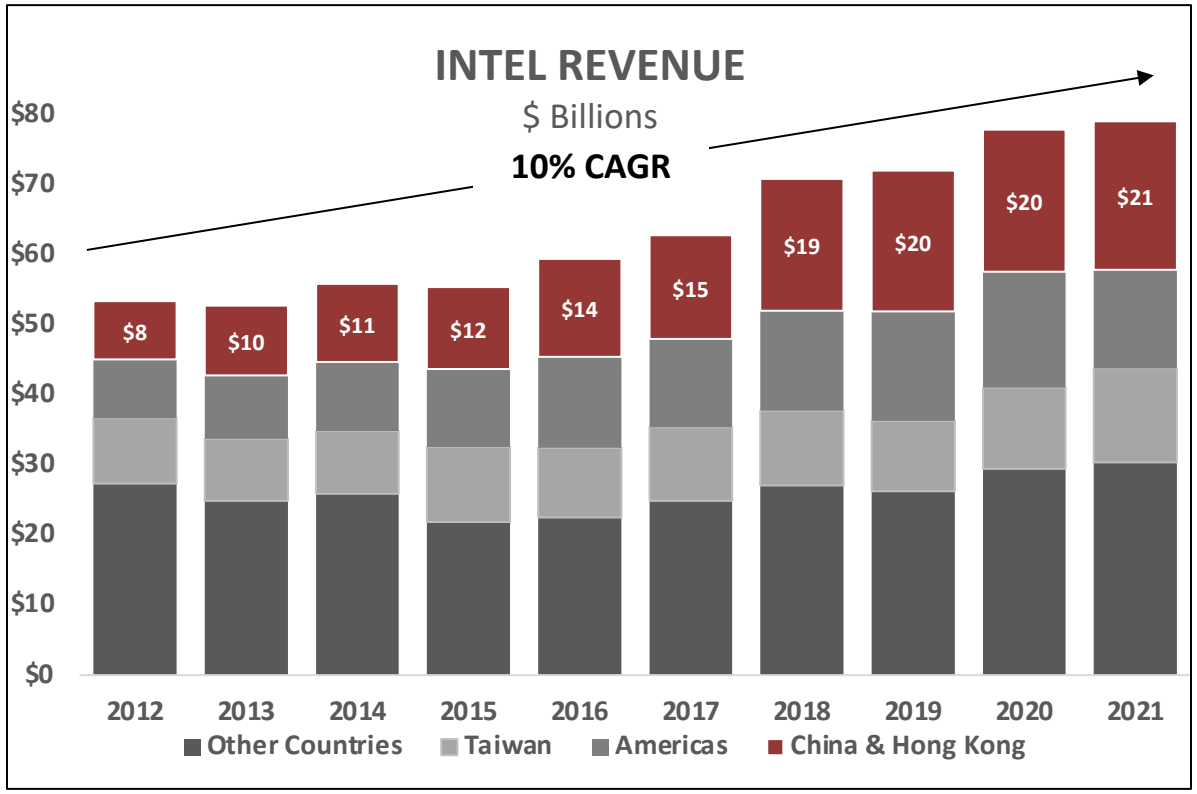


2019 Global Wafer Capacity



Sources; SIA 2019 Industry Report & Expert Interviews

High revenue exposure shows impossibility of total decoupling

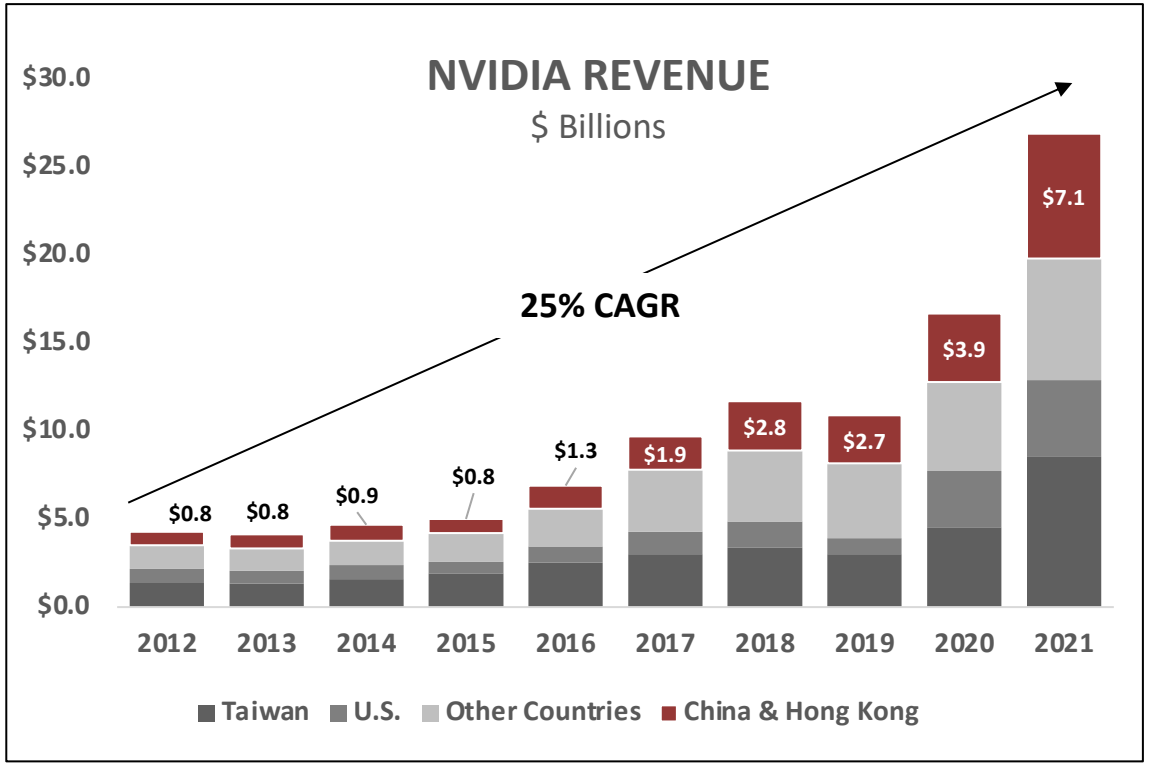


Integrated Device Manufacturer (IDM)

Fabless

23% Revenue Exposure

21% Revenue Exposure



Fabless

Two Cascading Hypotheses

Partial Decoupling Hypothesis & State of Innovation Hypothesis

Decoupling Hypothesis

Partial Decoupling

State of Innovation Hypothesis

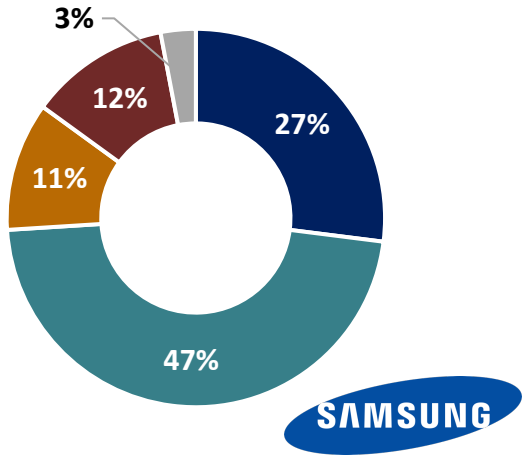
Hampering Semiconductor Innovation: The U.S.'s ability to cut-off Chinese access to the global advanced logic chip supply chain will hamper innovation.

Run Fast

Build Walls

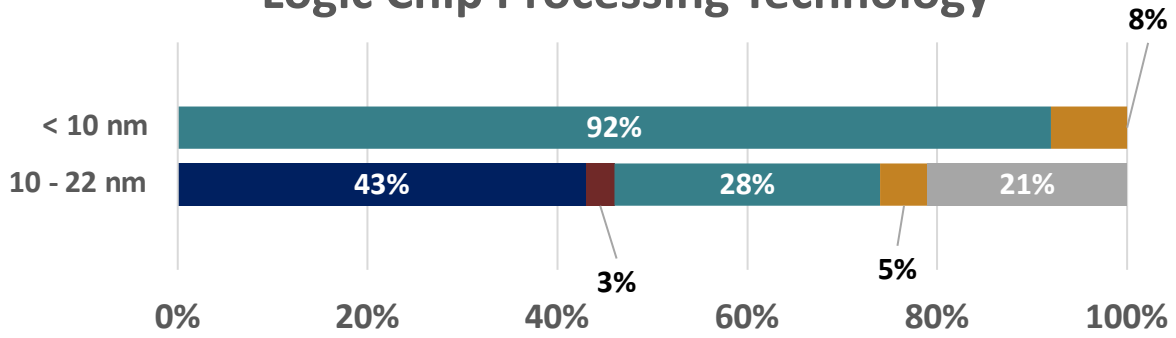
Taiwan & South Korea control advanced logic chip manufacturing

2019 Global Logic Chip Capacity (< 45nm)



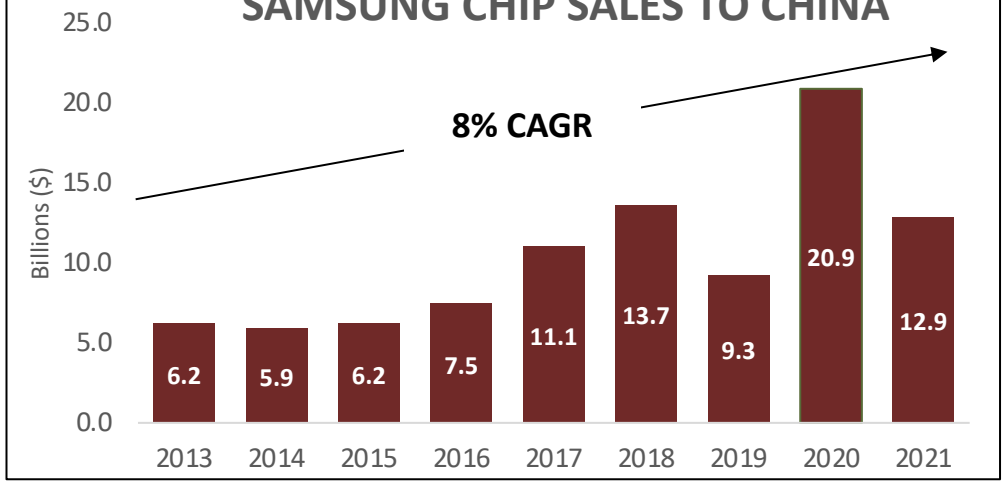
- U.S.
- Taiwan
- South Korea
- China
- Other

Logic Chip Processing Technology

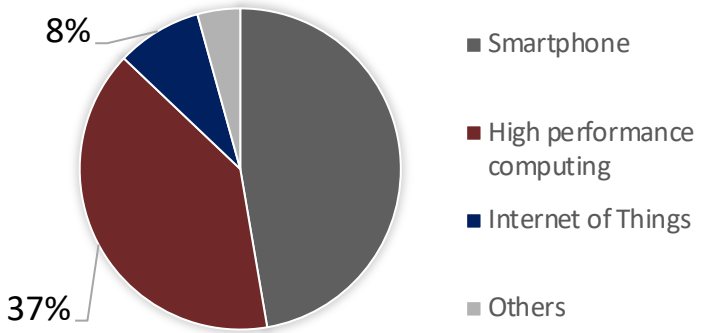


tsmc

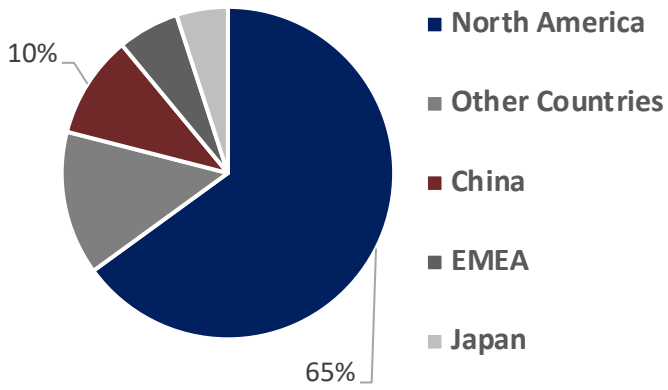
SAMSUNG CHIP SALES TO CHINA



TSMC 2021 REVENUE BY SEGMENT



TSMC 2021 PROFIT BY REGION



Sources: TSMC 2021 10-k filling, Win.d data & SIA 2021 Industry Outlook

Taiwan & South Korea control advanced logic chip manufacturing

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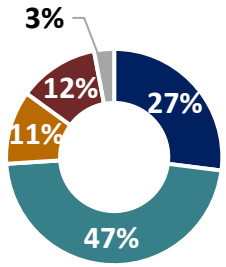
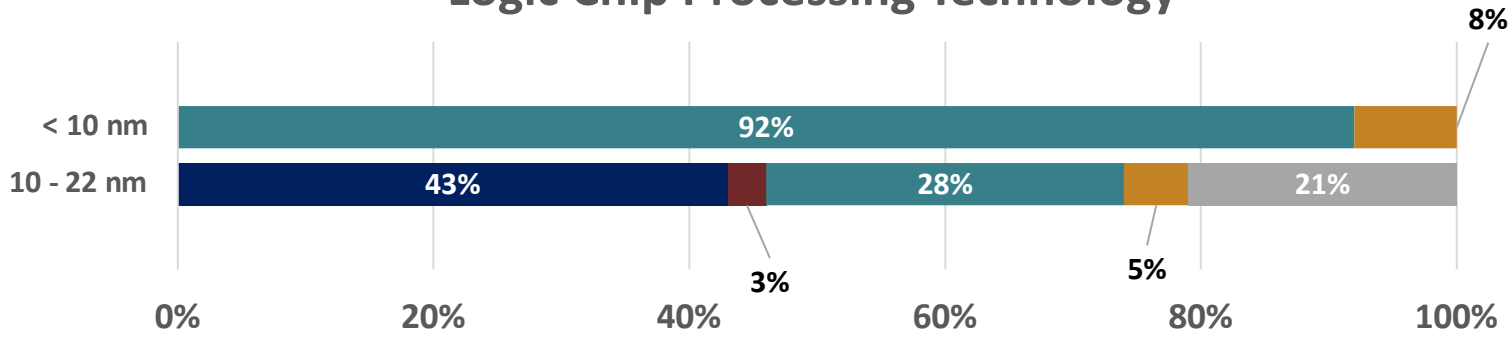


- U.S.
- Taiwan
- South Korea
- China

Logic Chip Processing Technology



SAMSUNG

tsmc

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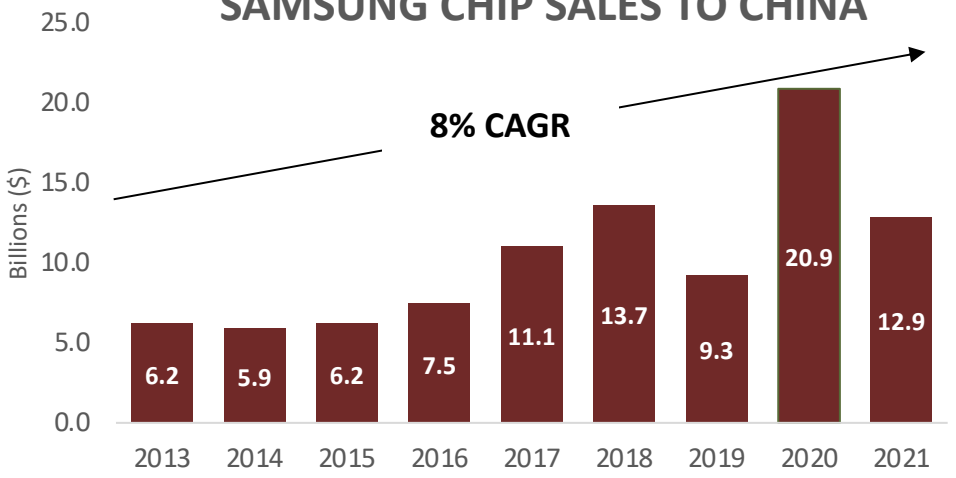

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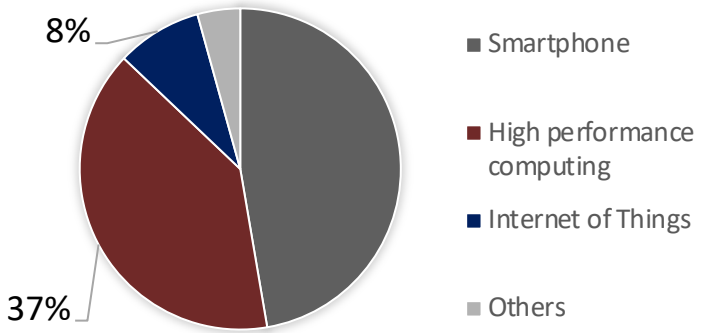

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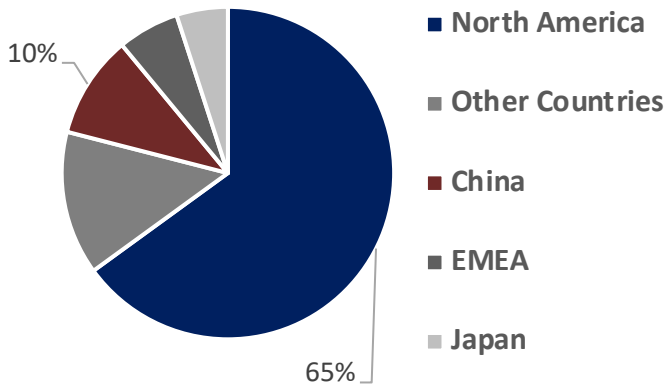


Sources: TSMC 2021 10-k filling, Win.d data & SIA 2021 Industry Outlook

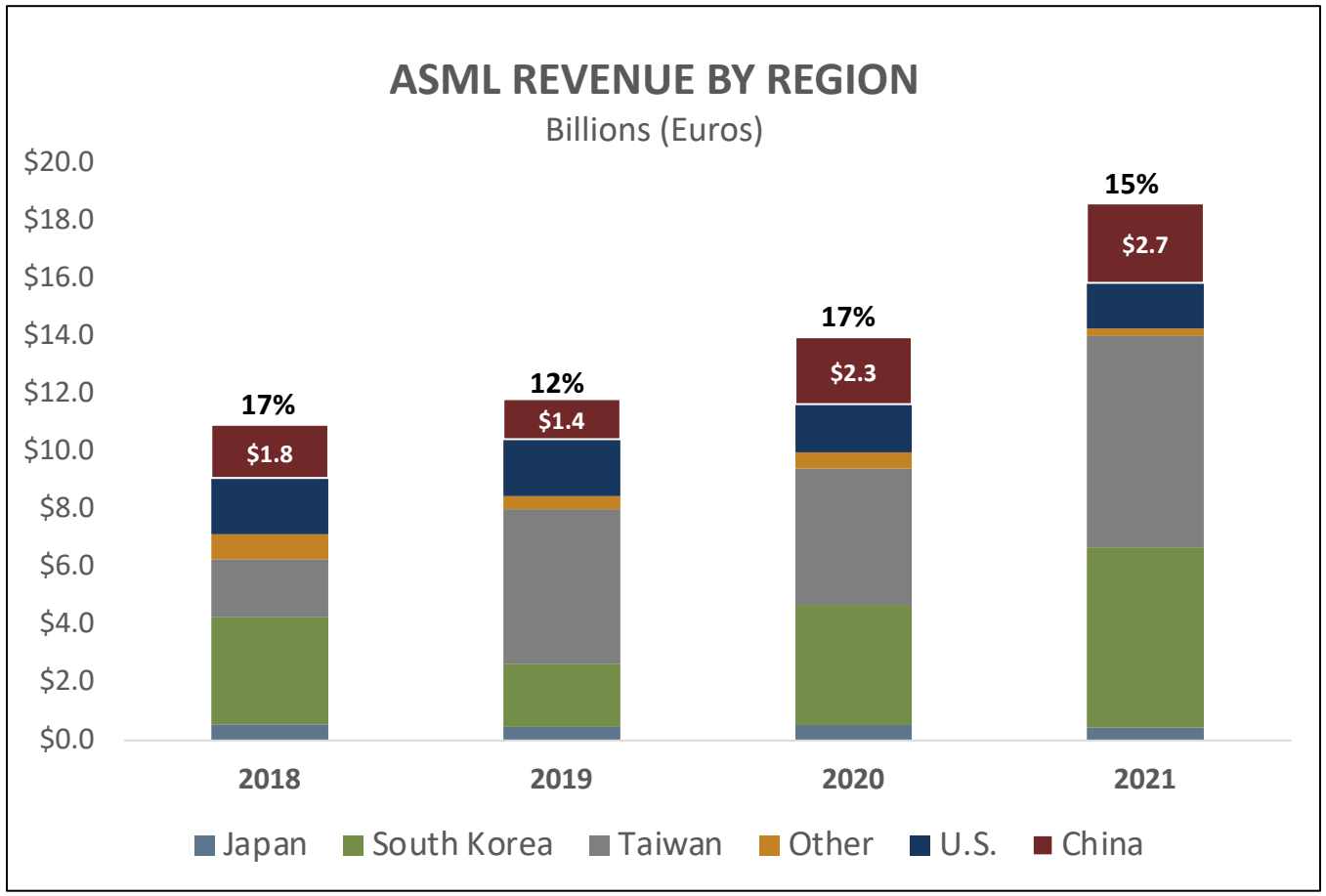
U.S. cannot leverage chokepoints over China alone

Advanced Logic Chip Input Producers

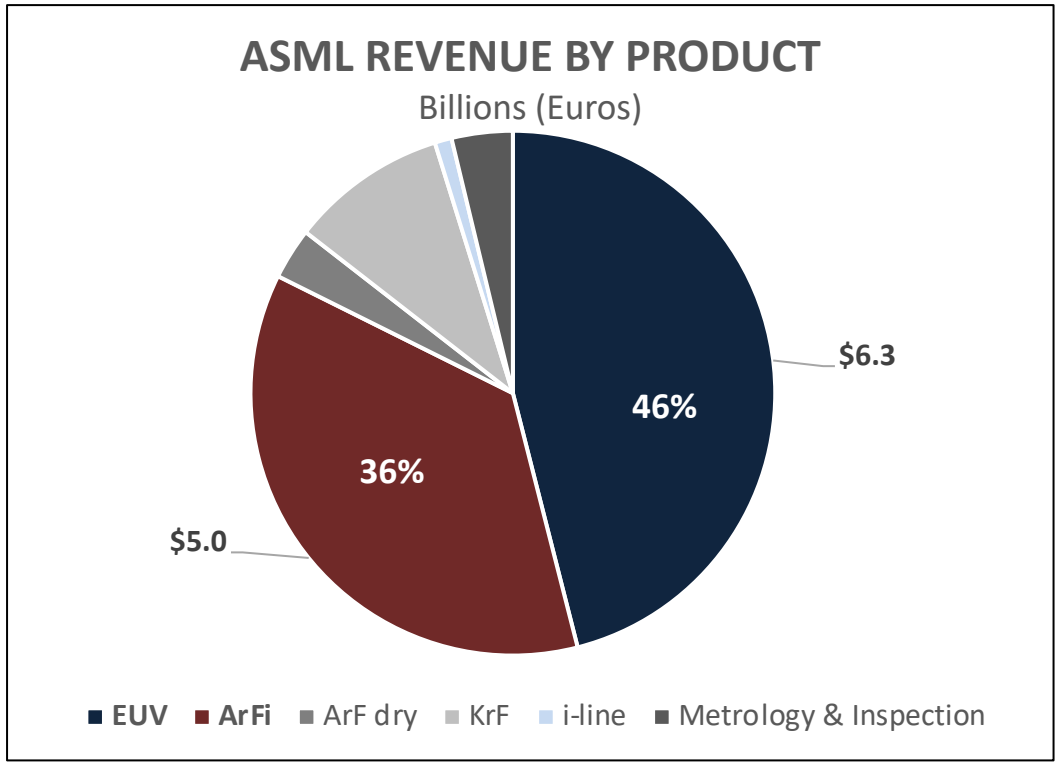
	Global Companies	U.S. Market Share	Chinese Market Share
EDA & Core IP	ARM	73.8%	1.2%
SME (Lithography)	Nikon, ASML	0.8%	0.2%

International firms rely on the Chinese market for revenue too

SME firms such as ASML have significant revenue exposure to China



15.3% Revenue Exposure

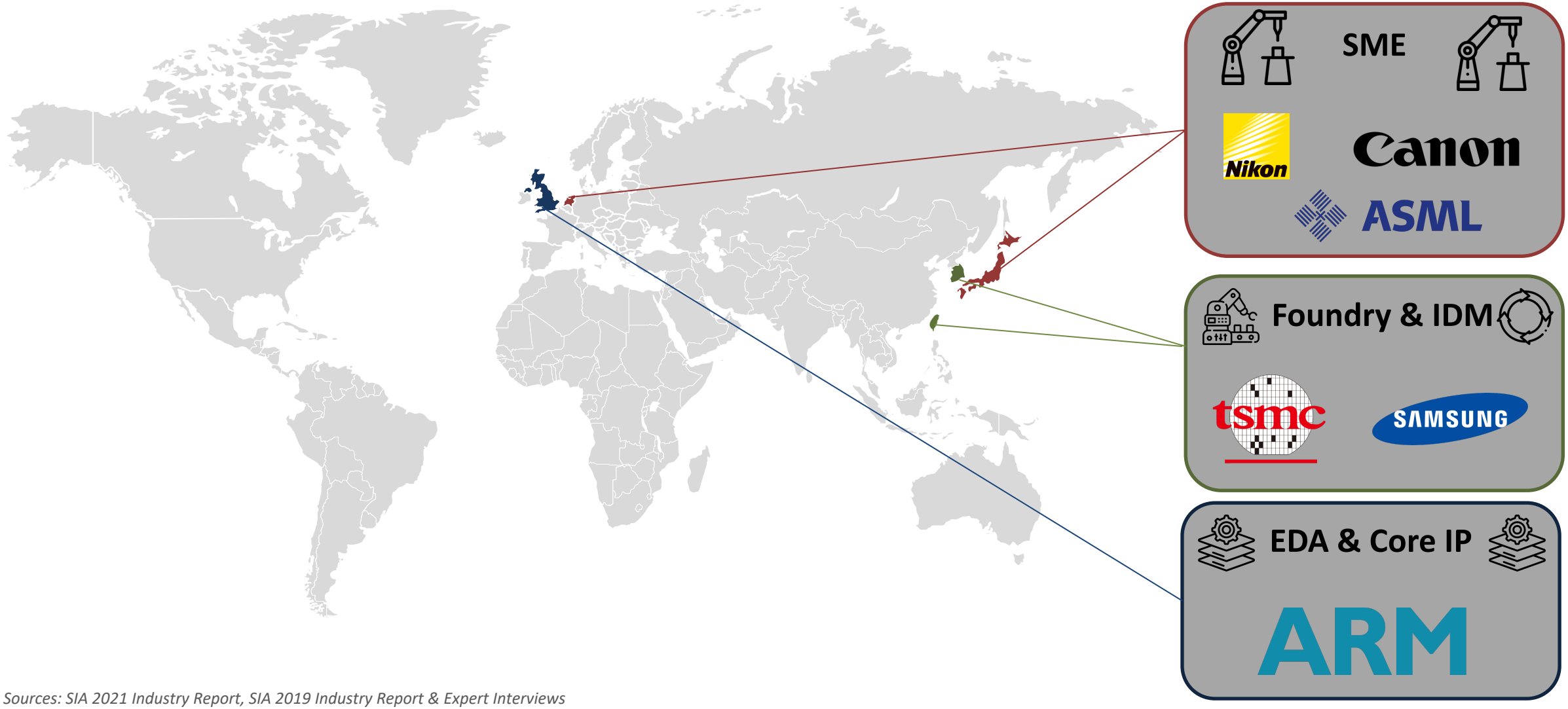


EUV lithography equipment is 46% of AMSL Revenue.

Sources: AMSL Annual 10-K filing

Netherlands, Taiwan & South Korea control input chokepoints

The U.S. is fully leveraging its influence over allies to ‘decapitate’ China’s domestic chip industry



Sources: SIA 2021 Industry Report, SIA 2019 Industry Report & Expert Interviews

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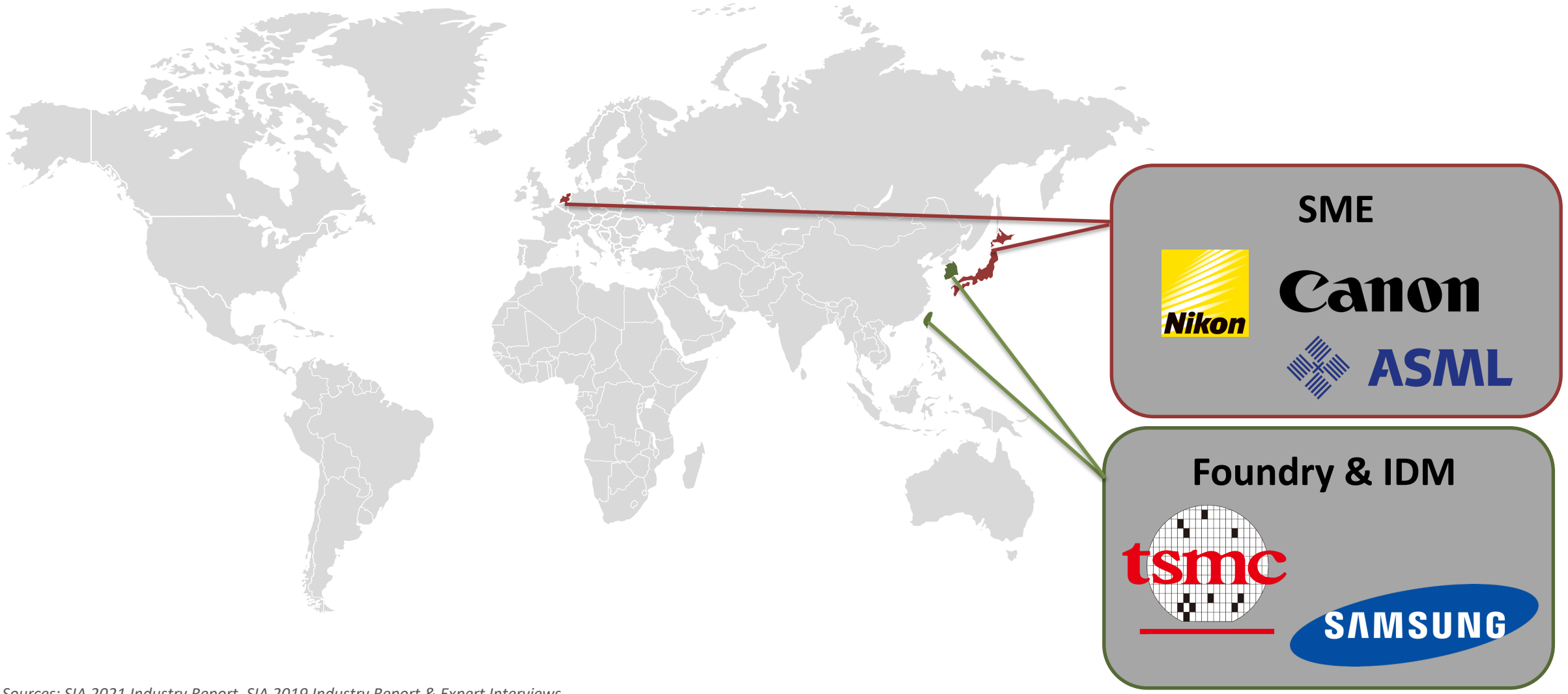

Sources: SIA 2021 Industry Report, SIA 2019 Industry Report & Expert Interviews

Targeted & Multilateral export bans on the value chain

The U.S. must demonstrate to its allies the danger of AI and protect allies from retaliatory bans from China

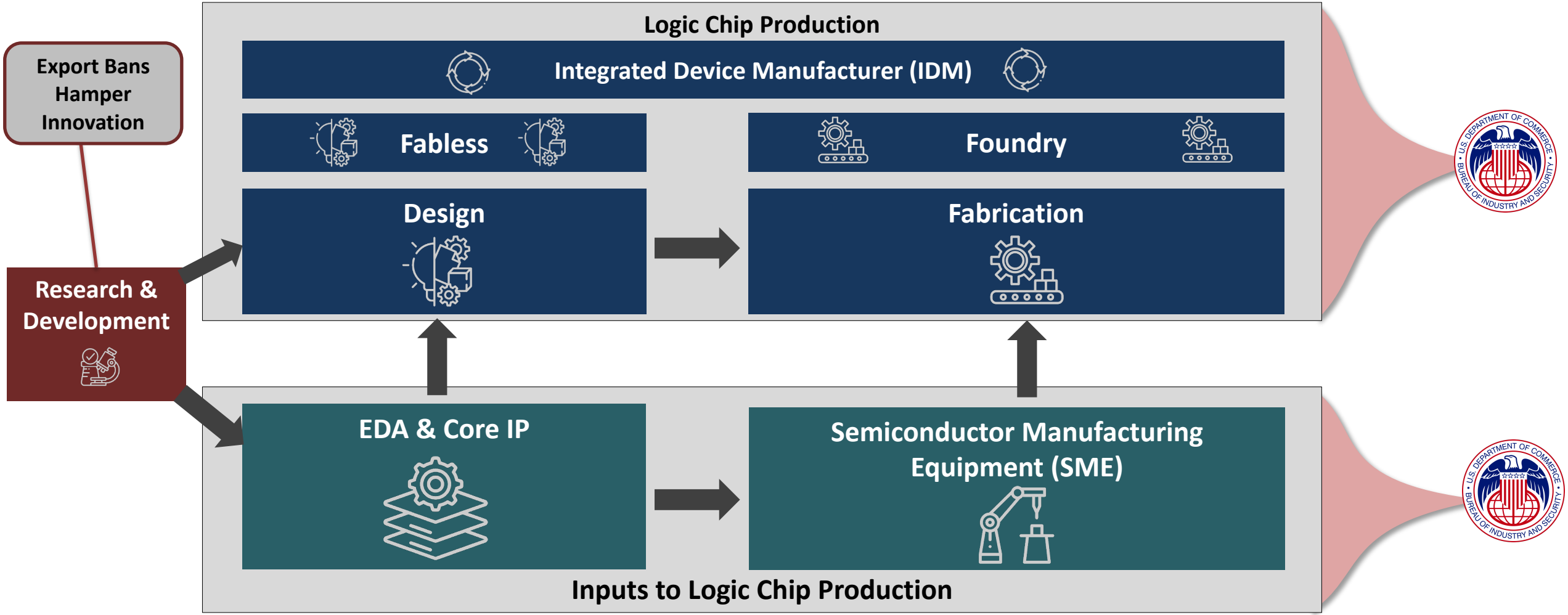

Table of Contents

An end to Moore's Law, government subsidies & enforcement

Governments will continue to invest in subsidies to domesticate or regionalize their supply chains

Build Walls

The CHIPS and Science Act

Security

U.S. DEPARTMENT OF COMMERCE · BUREAU OF INDUSTRY AND SECURITY

Enforcement Issues

HUAWEI

$206 million from 5 U.S. semiconductor companies

ZTE

$96 million from 5 U.S. semiconductor companies

Moore's Law: The *number of transistors on microchips will double every two years.*

"Moore's Law will likely come to end within the next 10 years, providing China with a window of opportunity to catch up" **– Government Source**

"The most important part of the CHIPS Act is the enormous amount of R&D funding for companies so they can continue to innovate" **– Academic Source**

18.6% R&D expenditure as a percent of sales

Sources: Expert Interviews

The End

Questions

Global supply chain has maintained the principles of Moore's Law

Globalized supply chain has allowed firms to utilize foreign IP & economies of scale to maintain a rapid pace of innovation