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EMBODIED AI HARDWARE

Physical AI Product Networks, Sensors, And Actuation Exposure

A client-facing screen for robots, vision systems, navigation, controls, sensors, and actuation hardware

PREPARED BY SYMBIOSIS UNITED ANALYTICS | VERSION 1.0

2024 U.S. CHINA-ORIGIN IMPORTS	TOTAL U.S. PLATFORM IMPORTS	GLOBAL CHINA-ORIGIN EXPORTS
$9.06B	$72.53B	$93.37B
ALLIED CHINA-ORIGIN IMPORTS	U.S. IO FOOTPRINT	FOOTPRINT MULTIPLIER
$53.30B	$13.04B	1.44x

CLIENT DECISION THIS REPORT SUPPORTS

Use this report to separate physical-AI adoption from the hardware platform that makes it operational: robots, machine vision, navigation, controls, sensors, power electronics, and actuation. The purpose is to identify which product lanes require supplier qualification, integration review, or monitoring before embodied-AI deployments scale.

Executive Brief For Decision Makers

Physical AI is embodied in hardware. The strategic exposure is not only the industrial robot; it is the stack of cameras, navigation devices, sensors, control boards, power converters, and motors that lets a machine perceive, decide, and move in the physical world. BACI records $72.53B of 2024 U.S. imports in the physical AI hardware platform, including $9.06B from China. China supplies 12.5% of measured U.S. imports in this platform, while China-origin exports to all destinations total $93.37B, or 23.5% of global trade in the measured HS6 universe.

The report's first point is segmentation. Controls and power is the largest U.S. import group in the screen, and Low-voltage control boards is the largest individual HS6 product lane. That does not imply that all exposure should receive the same action. Some lanes are primarily allocation and working-capital issues; others are supplier-qualification problems; still others require export-control, safety, firmware, or customer-approval review before a sourcing decision is meaningful.

The input-output screen translates the direct China-origin flow into U.S. production-network incidence. Using the 2020 OECD ICIO matrix, the direct $9.06B China-origin flow generates a modeled $13.04B U.S. gross-output footprint and a $6.12B value-added footprint. This is not a forecast and not a causal pass-through estimate. It is a disciplined exposure screen that turns customs flows into a map of downstream sectors that may feel the constraint.

Bottom line. The most useful management move is not to announce a generic China-exit strategy. It is to split the platform into decision lanes: protect price and delivery where purchases are active, qualify alternatives where origin concentration is high, maintain monitored exposure where substitution is not binding, and escalate product-specific legal or engineering review where HS6 evidence is too broad.

CLIENT RELEVANCE

Use this report when operations, procurement, robotics deployment, advanced manufacturing, logistics automation, and investor teams that need to distinguish an AI narrative from the hardware supply platform that must be qualified and maintained. The client-ready next step is to translate the HS6 screen into a deployment-level hardware bill of materials that identifies safety-critical parts, qualified suppliers, spare-parts exposure, firmware/calibration dependencies, and acceptable alternative origins.

Action Table

Business problem	Evidence	Recommended action	Horizon	Confidence
Deployment readiness	Physical-AI products combine robots, vision, sensing, controls, and actuation rather than a single customs line.	Build deployment BOMs around function: perceive, decide, control, move, and power.	0–90 days	High
China-origin exposure	China is directly visible in several hardware lanes, especially power, controls, cameras, and remote-control modules.	Prioritize qualification for high-China-share products before scaling automation programs.	0–12 months	High
Supplier qualification	Alternative origins exist, but product integration and safety requirements slow switching.	Treat supplier change as an engineering and certification process, not a spot-buying exercise.	3–24 months	Medium-high
Aftermarket and spares	Motors, sensors, control boards, and converters create repair and uptime exposure after deployment.	Add spares, firmware, calibration, and repair lanes to the sourcing register.	0–12 months	Medium
Scenario planning	HS6 data cannot reveal which products are AI-enabled, safety-critical, or customer-qualified.	Use the public screen to rank product lanes; use client BOMs to decide what can move.	Immediate	High

1 Scope And Method

This report estimates trade exposure and production-network incidence for the physical AI hardware platform. The product platform includes 27 BACI HS02 six-digit products grouped into 6 operating functions. The physical-AI platform is an HS6 proxy. BACI HS02 does not identify AI-enabled robots, autonomous drones, embedded software, safety certification, payload, sensor grade, or industrial integration. It measures broad robotics, camera, navigation, control, sensor, power-electronics, and motor categories that form the hardware base for physical AI.

The analysis uses two linked data systems. First, BACI HS02 V202601 provides bilateral product trade from 2005 through 2024. Values are reported in thousands of current U.S. dollars and quantities in metric tons. Second, the OECD ICIO 2023-edition small table provides a 2020 input-output matrix in current million U.S. dollars. For each country-industry column j, the technical coefficient is:

$$a_{ij} = \frac{z_{ij}}{x_j},$$

where z_{ij} is intermediate input flow from sector i to use sector j, and x_j is gross output. The downstream exposure model uses the U.S. domestic price-pressure inverse:

$$p = (I - A'_{US})^{-1} s,$$

where s is the vector of direct China-origin platform exposure allocated to U.S. use sectors. The method is descriptive. It is designed to prioritize diligence, not to predict realized margins, prices, shipment delays, or substitution success.

2 Direct Trade Exposure

The U.S. platform totals $72.53B in 2024 imports. China-origin imports are $9.06B, which means the measured China share is 12.5%. The largest U.S. import function is Controls and power at $37.43B; its China-origin share is 11.2%. These figures are useful because they show where executive attention should begin, but they do not settle whether a product can actually move. Qualification, product specification, legal classification, and customer approval remain product-specific.

Operating function	U.S. imports	From China	China share	HS6 count
Controls and power	$37.43B	$4.21B	11.2%	3
Vision systems	$16.17B	$2.43B	15.0%	4
Actuation	$6.14B	$939.6M	15.3%	6
Sensors and instruments	$6.10B	$622.0M	10.2%	5
Navigation and sensing	$5.85B	$835.0M	14.3%	7
Robots	$832.6M	$30.0M	3.6%	1

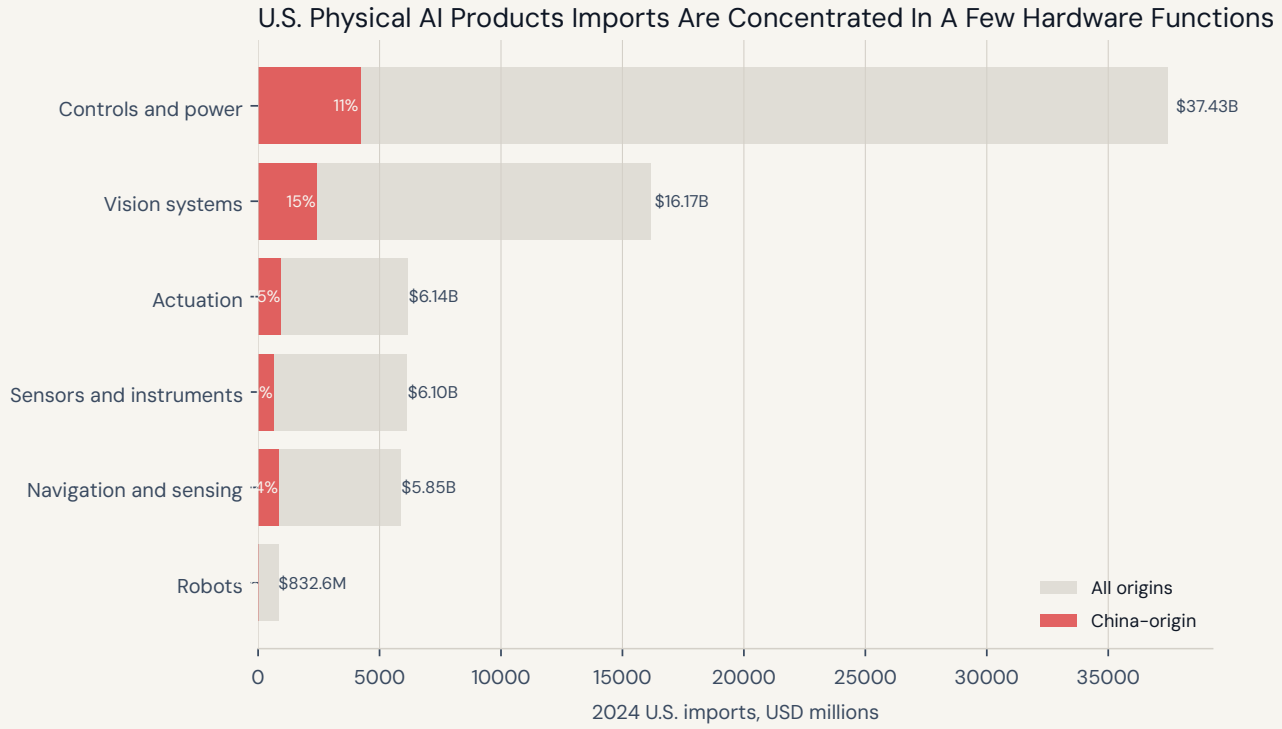

Figure 1: 2024 U.S. import exposure by operating function. Bars show total U.S. imports and the China-origin component in the HS6 proxy platform.

HS6	Product proxy	U.S. imports	From China	China share	HHI
853710	Low-voltage control boards	$18.68B	$1.26B	6.8%	0.21
850440	Static converters	$17.58B	$2.90B	16.5%	0.09
852540	Digital cameras	$9.45B	$1.63B	17.2%	0.11
903180	Measuring/checking machines	$3.88B	$250.8M	6.5%	0.07
850131	DC motors/generators <=750W	$2.75B	$412.6M	15.0%	0.17
850110	Small electric motors	$2.31B	$409.4M	17.7%	0.12
902780	Physical/chemical analysis instruments	$1.96B	$136.2M	7.0%	0.11
902620	Pressure instruments	$1.88B	$250.3M	13.3%	0.12

The HHI column measures origin concentration inside U.S. imports for each HS6 product. High China share and high HHI signal a substitution problem; high import value with low China share signals a working-capital, allocation, or monitoring problem; high strategic relevance with low measured customs value can still be urgent if the product is safety-critical or customer-qualified.

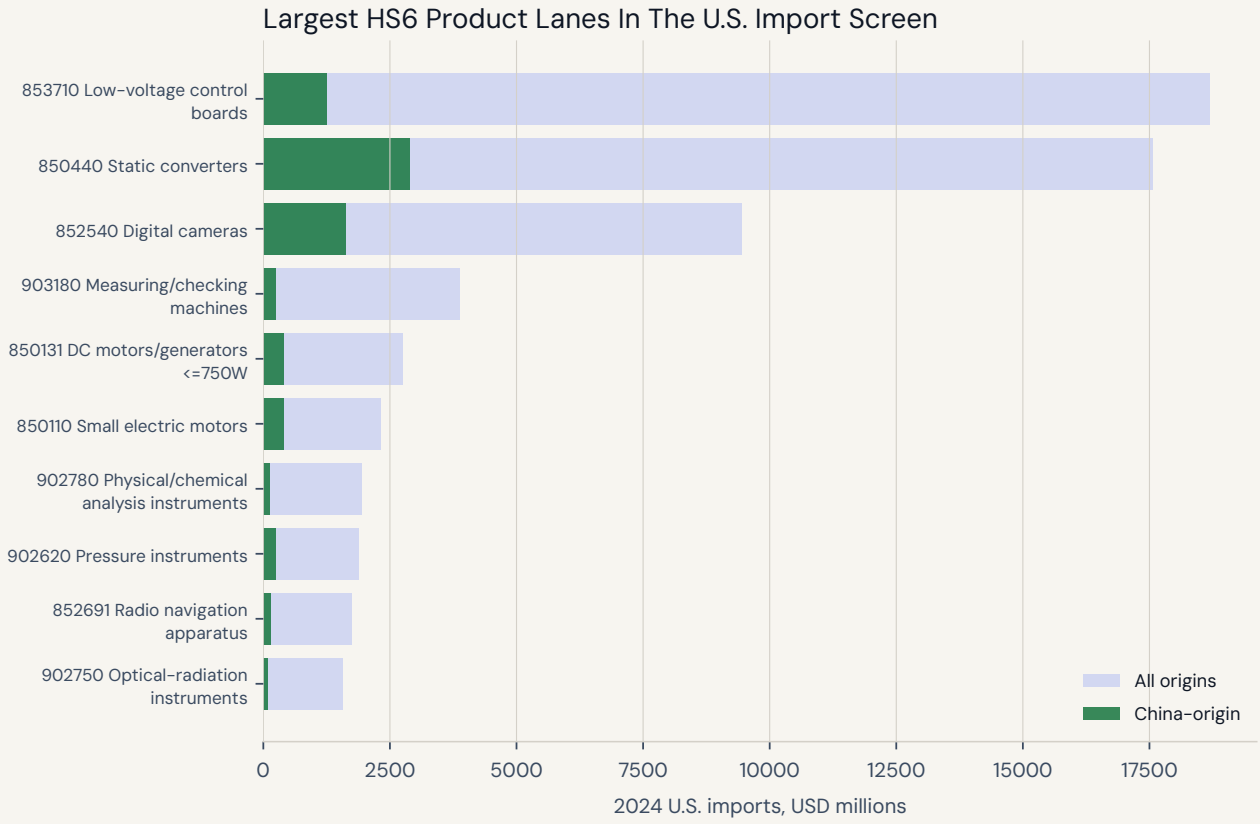

Figure 2: Largest HS6 product lanes in the 2024 U.S. import screen. The China-origin component is shown inside the broader import base.

3 Time Trend And China Position

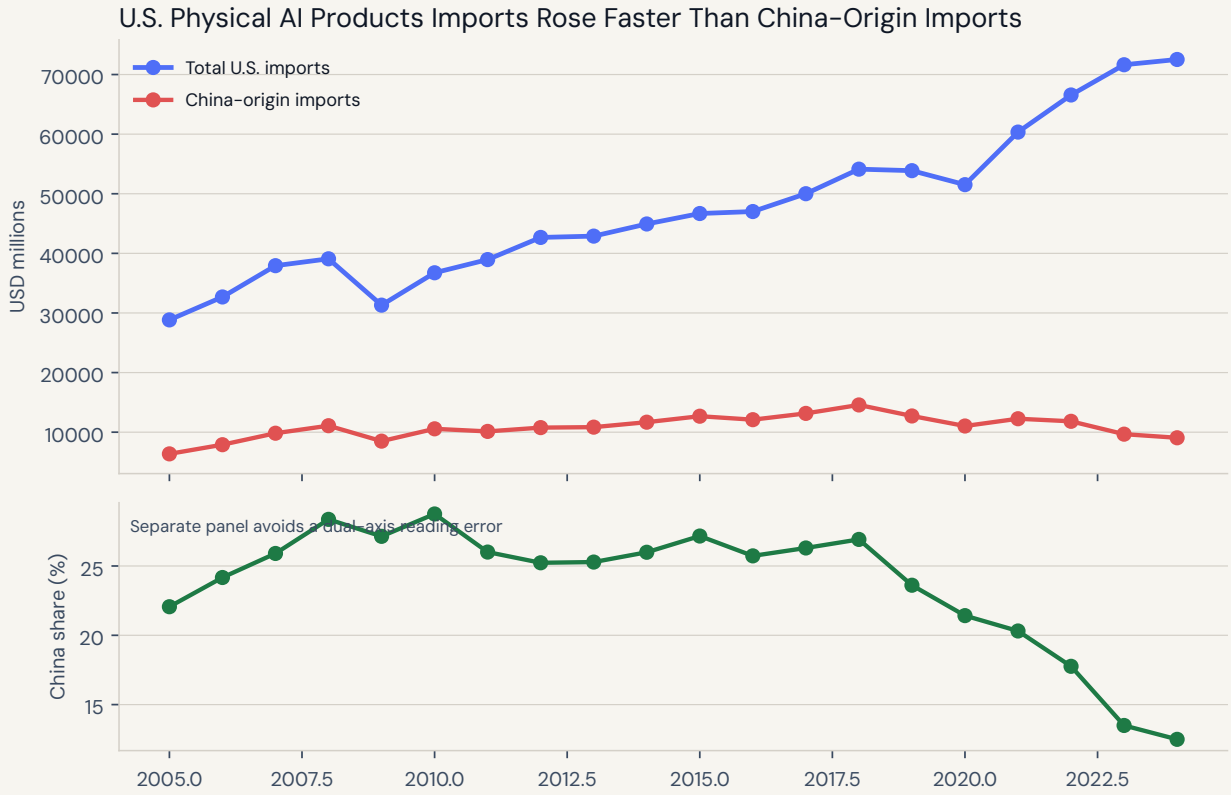

Figure 3: U.S. platform imports and China-origin share, 2005–2024. Values are current U.S. dollars in the BACI HS6 proxy universe.

U.S. imports in the platform increased from $28.84B in 2005 to $72.53B in 2024. China-origin U.S. imports increased from $6.36B to $9.06B. The time series therefore separates scale from dependence: a platform can become larger and more strategically important even when its measured China share does not rise one-for-one.

China's position is global, not only bilateral. China-origin exports in the platform are $93.37B, and China-origin shipments to allied economies in the report definition are $53.30B. That allied pool is important for client work because substitution pressure often arrives through customer requirements, government procurement rules, or resilience mandates even when the immediate U.S. customs exposure is manageable.

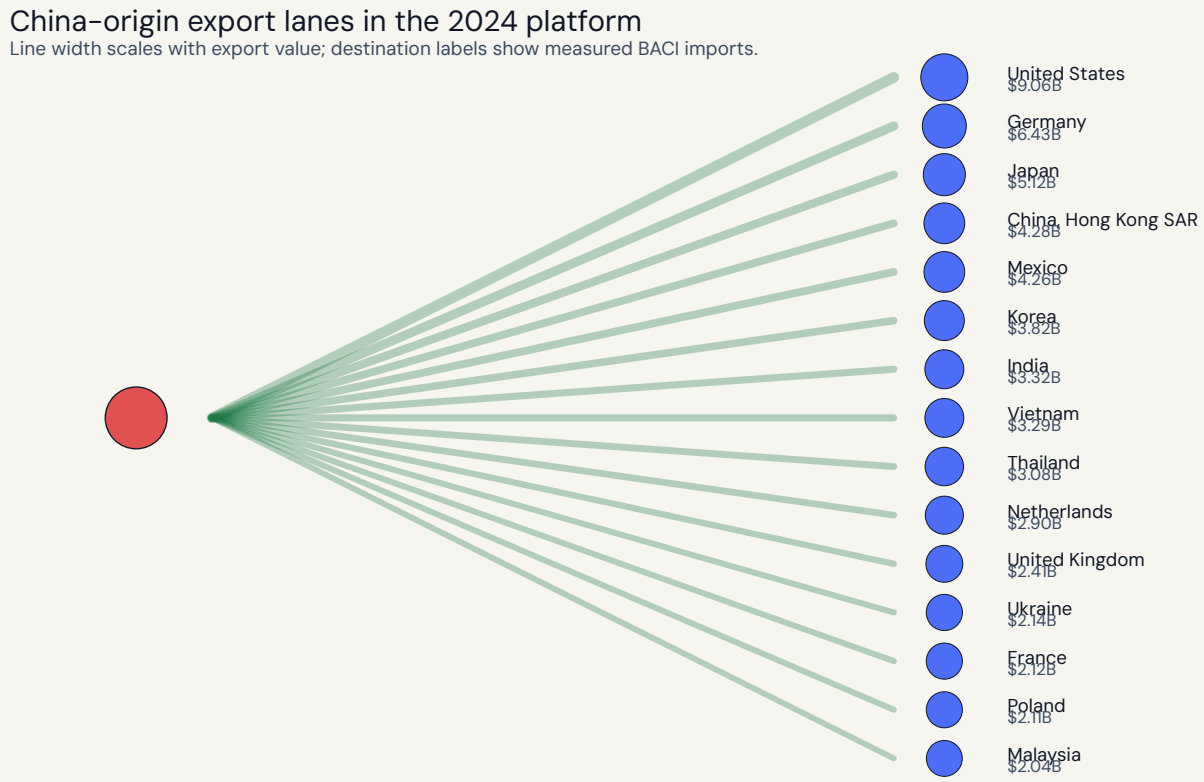

Figure 4: Largest China-origin 2024 export lanes in the platform. Line width reflects trade value; destination labels show measured BACI import values.

4 Supplier Platforms And Substitution Screen

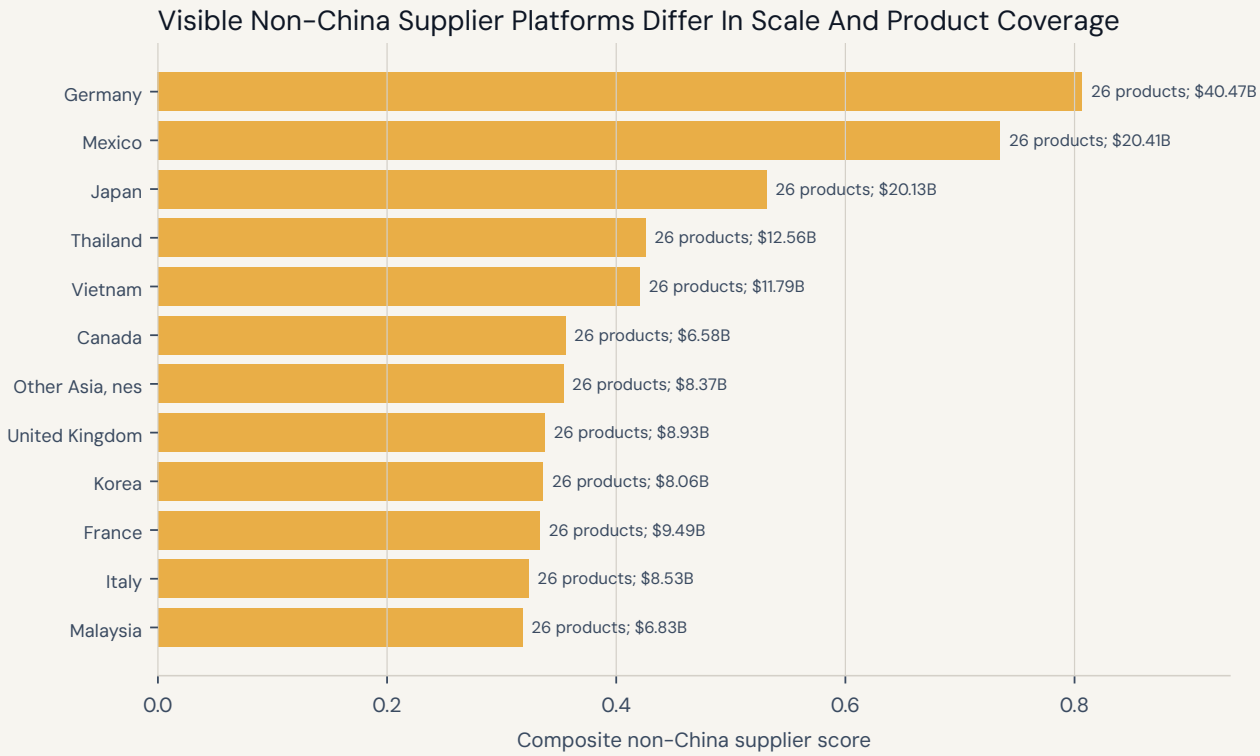

Figure 5: Visible non-China supplier platforms in 2024. The score combines global export scale, U.S. import presence, and product coverage across the HS6 platform.

The substitution screen is not a list of approved suppliers. It is a way to distinguish visible trade platforms from narrative alternatives. Countries that score highly already export across multiple products and appear in U.S. import lanes. That visibility reduces search cost, but it does not prove spare capacity, quality fit, licensing eligibility, firmware support, safety certification, or customer approval.

Candidate origin	World exports	U.S. imports	HS6 count	Score
Germany	$40.47B	$5.45B	26	0.81
Mexico	$20.41B	$16.26B	26	0.73
Japan	$20.13B	$4.63B	26	0.53
Thailand	$12.56B	$4.14B	26	0.43
Vietnam	$11.79B	$4.43B	26	0.42
Canada	$6.58B	$4.54B	26	0.36
Other Asia, nes	$8.37B	$3.11B	26	0.35
United Kingdom	$8.93B	$1.75B	26	0.34

5 Input-Output Propagation

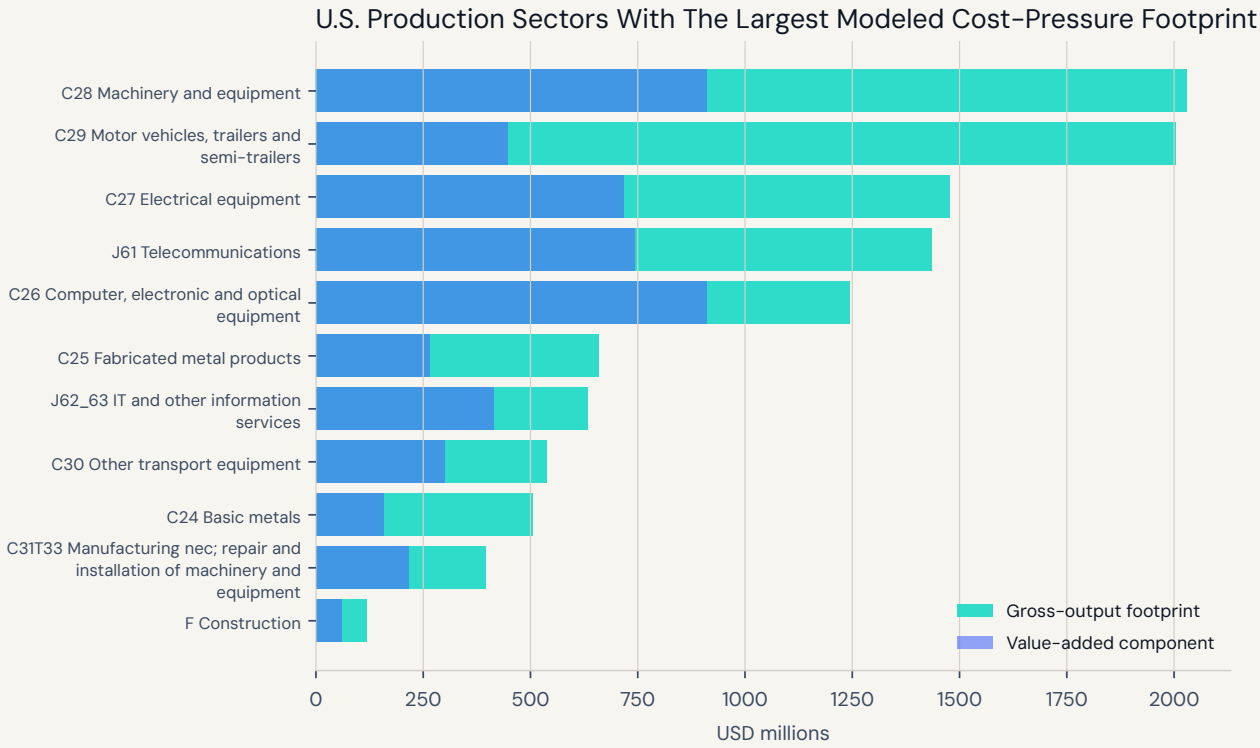

Figure 6: U.S. downstream sectors with the largest modeled gross-output and value-added footprint. The screen allocates direct China-origin platform exposure through the U.S. ICIO production network.

The model allocates direct China-origin platform exposure into U.S. use sectors and applies the domestic input-output inverse. The resulting gross-output footprint is $13.04B, or 1.44 times the direct China-origin flow. The value-added component is $6.12B. The interpretation is cost-pressure incidence, not realized pass-through. It tells a client where to ask the next operational question: which business unit uses the hardware, which suppliers are qualified, which customer contracts permit cost recovery, and which product lines cannot tolerate downtime.

ICIO	U.S. use sector	Direct	Gross output	Value added
C28	Machinery and equipment	$1.78B	$2.03B	$909.9M
C29	Motor vehicles, trailers and semi-trailers	$1.52B	$2.00B	$446.9M
C27	Electrical equipment	$1.30B	$1.48B	$716.3M
J61	Telecommunications	$1.24B	$1.44B	$741.8M
C26	Computer, electronic and optical equipment	$1.18B	$1.24B	$909.5M
C25	Fabricated metal products	$485.2M	$657.9M	$265.3M
J62_63	IT and other information services	$553.3M	$632.1M	$412.8M
C30	Other transport equipment	$377.4M	$538.0M	$299.8M

6 90-Day Client Action Plan

The first operating cycle should convert the public screen into named owners and dated decisions. Procurement should rank the top HS6 products by import value, China share, origin HHI, and business criticality. Trade compliance should map HS6 proxies to HTS10, origin documentation, and any applicable controls. Finance should stress test landed cost, inventory timing, working-capital needs, and customer recovery. Engineering or operations should decide which products can be dual-qualified and which require redesign, recertification, or customer approval.

Timing	Decision focus	Owner set	Output
Day 0–30	Convert HS6 exposure into HTS10, supplier, site, customer, and contract records.	Trade compliance, procurement, finance	Exposure register with named owners.
Day 30–60	Split products into price-protection, dual-qualification, redesign, and monitor-only lanes.	Procurement, operations, legal	Decision lane for each major product family.
Day 60–90	Validate alternative origins, quality gates, lead times, firmware/calibration needs, and customer-approval constraints.	Engineering, quality, procurement	Qualification plan and exception list.
Quarterly	Refresh BACI screen, policy changes, supplier market signals, and customer requirements.	CFO, COO, category leaders	Updated platform risk memo.

7 Technical Appendix

Data. The analysis uses CEPII BACI HS02 V202601 bilateral goods trade with local HS-to-ISIC mappings for 2005–2024. Values are current U.S. dollars. Product descriptions and HS6 concordance text come from the BACI product concordance in this repository.

Input-output model. The ICIO screen uses the OECD ICIO 2023-edition small table for 2020. Direct China-origin platform imports are allocated to selected U.S. use sectors using 2020 intermediate input shares from the relevant broad ICIO input sectors. The resulting footprint is a descriptive cost-pressure screen.

Limitations. The report does not identify firm suppliers, contractual prices, product-grade differences, export-control classifications, safety certifications, firmware dependencies, customer approvals, or real-time capacity. The product scope is broader than AI-only hardware. The report is intended for prioritization before client-specific diligence, not as a final sourcing decision.