China's Self-Reliance Goal: How Much Progress?

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Introduction

Technological self-reliance has become an important objective of China's industrial policy since 2020. Moreover, increasingly specific and targeted policy instruments are being used to reduce import dependence on narrowly and precisely defined commodities. In this paper we assess the extent to which China has in fact become "less dependent" on technology-embodying imports of the past ten years. Has China become more self-reliant? We address this question both at the aggregate and specific commodity levels. We first briefly examine China's imports of industrial intermediates and capital goods from the aggregate, or macroeconomic, perspective. We find significant, but not extremely large, reductions in overall import dependence. We then proceed to the microeconomic level and analyze imports at the individual commodity level. We develop a list of commodities that is based on Chinese articles identifying areas of significant technological vulnerability. Our initial batch of commodities is based on a widely circulated list of technological vulnerabilities from 2018. We then supplement the analysis with two additional "batches" of sensitive technologies, released in 2023 and 2025 respectively, which provide external validity checks. The core analysis is based on a list of 85 products that we derived by converting "technologies" to "products," to the best of our ability. We cluster these 85 products into 16 technology groups (a 17th group is added later for comparison). We then monthly import trends for these products at the HS 8-digit level, provided by China Customs through 2024 and the first four months of 2025.

The commodity-level analysis produces a complex picture, since individual commodity imports fluctuate monthly and display divergent short-run trends. We have prior beliefs about trends in the semiconductor sector, which is the focus both of U.S. efforts to restrict Chinese imports and a very large Chinese effort to build out their domestic sector. However, we are interested in identifying sectors based primarily on the trade data. We use a simple decision rule, based on a two-by-two matrix of growth and variability, to identify imports into four categories. The first category consists of three technology groups (mostly semiconductor-related) that display high variance and high growth, likely the result of policy interventions. The second category consists of seven technology groups comprising rapidly growing, low volatility imports. This implies a lack of import substitution, and these are often high-technology capital goods. The third and fourth categories display slow growth (or decline). We equate this to successful import substitution, and it includes seven groups, of which six also display low volatility (the exception is Aviation and Aerospace). The individual commodity data is thus consistent with a picture of substantial technology import substitution across a wide range of technology-embodying imports.

We propose that the industry-level trends we observe reflect a policy-induced cycle of response. In the early period, before and after a technology is targeted for import substitution, imports tend to increase. This may reflect an exogenous market-driven signal that attracts the attention of policymakers to this sector. It may also reflect a policy choice: allowing imports to grow (a) builds familiarity among customers, creating a more substantial market, and also (b) gives producers more opportunity to replicate, reverse engineer, and replace the import. When these downstream and upstream conditions are in place, import substitution can take place more smoothly. Our 17th product group—medicines—is introduced mainly to provide a perspective on this import substitution cycle.

Our final step is to remove the impact of policy-induced stockpiling from the aggregate data, by subtracting imports in the high volatility and high growth category from aggregate import categories in every year. When this is done, China's progress in reducing import dependence is more conspicuous and more clearly focused on a few sectors. For example, from 2015 to 2024 capital goods imports (excluding semiconductor equipment subject to stockpiling) declined from 2.06% of GDP to 1.27% of GDP. The importance of capital goods imports to the Chinese economy declined by 38% over this nine-year period, a very substantial shift. To be sure, China's imports have been weak since 2021, declining in the aggregate from 15.1% of GDP to 13.6% in 2024, so some part of the decline in capital goods imports is simply weak uptake from a sluggish economy. Nevertheless, it seems that technology import substitution is an important trend and is itself an important contributor to the slow growth of imports.

A final section discusses possible implications of the research, including limitations. The work here should be considered preliminary, more like a pilot study than a full research program. We have not examined exports at all, considered the impact of foreign-invested firms, or the influence of global value chains. Future work should seek to integrate those perspectives and expand the list of commodities analyzed. Moreover, we are maintaining an assumption that import trends are closely related to industrial policy. Yet there is substantial endogeneity inherent in industrial policy, and we have not attempted to establish causal relationships between policy inputs and the degree of trade dependency. Instead, our analysis is descriptive, based on Chinese designation bottleneck commodities, to trace observable trade patterns over recent years.

Even at this early stage, the analysis uncovers two potentially profound implications. First, the cost to China of this policy is likely to be large and diffused through the economy. Lower quality and higher cost industrial inputs—both capital goods and intermediates—are likely to be the short-run effects of the policy. Whether long-run upgrading offsets this cost is highly uncertain. Second, a China that systematically reduces its import reliance while simultaneously seeking to expand exports inevitably implies destabilizing trade imbalances extending into the foreseeable future. This will likely become a huge geopolitical and economic handicap to China.

1. The Objective of Self-Reliance.

Self-reliance has not traditionally been considered as a primary objective of industrial policy. However, China has clearly moved from industrial policy as a primarily economic quest for "new growth drivers" and dynamic leading sectors, toward a steadily increasing emphasis on security and self-reliance. Naughton, Xiao and Xu (2023) proposed a three-stage periodization of China's industrial policy, with the third stage, beginning in 2020, clearly focused on technological independence and reduction of external dependencies. This occurred after the beginning of the trade war with the United States, and after the arrival of COVID initially led Chinese policymakers to expect a significant disruption in external trade.

The policy of "dual circulation" was advanced, which had ambiguous elements but clearly envisioned boosting domestic supply to fill gaps left by reduced imports. The 14th Five Year Plan, drafted in 2020 and promulgated in 2021, explicitly called for "scientific and technological self-reliance and self-strengthening" (科技自立自强). This has been official Chinese policy ever since. For example, on November 5, 2024, Xi Jinping called for "achieving high-level self-reliance and strength in science and technology," when he visited the Wuhan Institute of Industrial Innovation and Development.

Within this third stage, recent years have witnessed a dramatic focus on specific targeting of individual technologies and products. Chinese reports are full of reports about "choke points" (卡脖子), a graphic way to refer to import dependencies. We will generally refer to these as "bottleneck" technologies and commodities, meaning items identified in official or semi-official Chinese sources as vulnerabilities that call for reduction of dependency. Considerable effort has been and is being put into the identification of import dependencies. For example, the annual "Green Book" series of technology roadmaps—the 2023 edition is over 500 pages—designate specific technologies, components and materials in which China remains import dependent (we utilize these in the work below). These roadmaps articulate objectives to replicate domestically the capabilities embodied in current imports, and qualitative targets are given for 2025, 2030 and 2035 (Green Book 2023). As the authors acknowledge, this project is a direct descendent of the technology roadmaps published as early as 2015 as part of the "Made in China 2025" program. While the program is now labeled the "Powerful Manufacturing Nation," (制造业强国) and the authors carefully avoid publicly releasing quantitative targets or using the term "Made in China 2025," the continuing effort is now far more elaborate, including the designation of specific technologies and technology-embodying goods, including components and materials.

In parallel, Chinese policymakers have increasingly promoted new policy instruments that can more effectively intervene in targeted areas. The most obvious example of such an instrument is the Innovation Consortium (创新联合体), hundreds of which have been established across China since 2021. These consortia are established with a leading organization, typically an enterprise, and a coordinating body. The consortium unites entities from the beginning to the end of the innovation chain, linking them with specific technical targets, contractual obligations, and rewards (Groenewegen-Lau 2024; Naughton, Xiao and Xu 2024). It is an organizational form specifically tailored to attack a specific technological target by tying together the different types of capabilities needed—scientific research, engineering development, prototyping, and mass production—in order to overcome shortcomings and dependencies (Groenewegen-Lau and Laha 2023). Innovation Consortia, alternately stated, are targeted microeconomic institutions that fit within a broader program of self-reliance and systematically reduced dependencies. The broader program has recently been encapsulated by the term "modernized production system" (现代化产业体系), which has been declared the top economic priority for most of the past few years. Its goal is essentially to replicate within China the entire global network of interdependent production and services. In other words, it is based on an understanding that true self-sufficiency requires replicating domestically the full range of specialized service providers and niche industrial producers that serve the global economy. This is a grand vision that stresses the advantages of China's comprehensive and diverse industrial base, and emphasize the importance of maintaining what we might call "completeness." To be sure, it is often discussed in the context of arguing for upgrading—rather than abandoning or offshoring—traditional labor-intensive manufacturing sectors (Han 2023; Wei 2022). However, it is unmistakable that the fundamental objective is to have a complete and self-reliant industrial system, preferably reducing external dependency to zero. In some versions, the "completeness" of the industrial system is argued as an economic and technological benefit in itself (Lu Feng 2025).

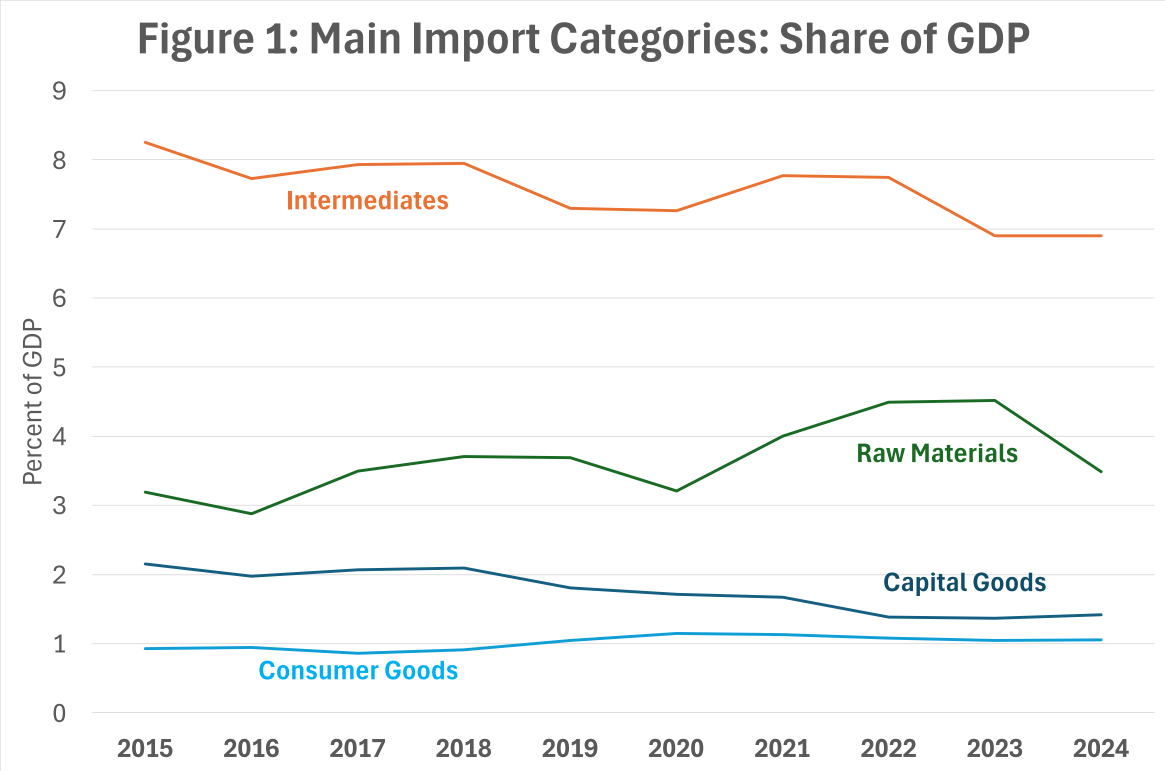
This amounts to a qualitatively different kind of industrial policy. It is true that various kinds of import substitution have been part of East Asian industrial policy for decades (for example, in Taiwan, see Wade 2003). However, the objective was to identify and support infant industries that could subsequently grow strong enough to enter world markets. Policymakers would designate priority "leading sectors" and the support for these sectors was implicitly embedded in a rotation of economic sectors that would continue indefinitely and sustain economic openness. Chinese policy evolved through this stage as well: the original intent of "indigenous innovation" was simply to build domestic capability, and the original "Strategic Emerging Industries" were designated in 2010 because of their potential to become export leaders (and indeed, that has now happened with electric vehicles). The effort to build domestic capabilities is a constant through many phases of industrial policy, but the earlier efforts involved participation in the global division of labor and an emphasis on sectors in which China had, or could develop, comparative advantage. Today's policies have very different goals. Self-reliance must be taken as a separate objective valued by Chinese policymakers for its own sake. It often involves investing in sectors precisely because China does *not have* comparative advantage in those sectors, as revealed by their dependence on imports. The economic logic is quite different, and we should therefore evaluate it on its own terms: This paper takes a tentative step in that direction.

2. Aggregate Import Categories: Definitions and Trends

A nation's trade goods are traditionally divided into four broad economic categories (BEC): raw materials, intermediate goods; capital goods; and consumption goods. Both intermediates and capital goods are used in further production, but capital goods become durable parts of an economy's production base. An industrializing nation's capital goods imports are perhaps the most direct measure of that nation's technological dependence on outside countries. Capital goods embody the most sophisticated technologies, and the production of capital goods worldwide is often dominated by specialized firms with extraordinary capabilities and, often, long histories. Capital goods combine pure scientific and technological knowledge with the "learning by doing" expertise that comes from long practice and refinement. The category of intermediate goods importantly includes parts and components, and these can also embody significant technology capabilities. Moreover, imports of intermediates are much larger than those of capital goods. For China, by far the largest category of intermediate goods is semiconductors. Many of China's semiconductor imports are near the technological frontier, and all have significant technology content.

The BEC are recorded and published by international organizations, including the World Bank and the United Nations Statistics Division. Unfortunately, the definitions of capital goods in trade data are not consistent across time or among countries (or even, sometimes, logically). The WITS data available through the World Bank data website are inconsistent and should not be used for serious analysis. The UN Comtrade site has shifted over time from BEC4 to BEC5, removing some inconsistencies but making it more difficult to compare trends over time. China shifted over from BEC4 to BEC5 in 2024. We used concordances between BEC4 and BEC5 to harmonize the data under the two classification systems; used China Customs published growth rates for specific commodities, and (after verification), constructed consistent BEC4 data that covers the entire 2015 through 2024 period. As detailed in Appendix B, we combined data from UN Comtrade statistics with Chinese Customs data (primarily growth rates), thereby generating new monthly and annual data series. This allowed us to use the detailed (HS8 individual commodity level) and timely (monthly data with a lag of only about two months) data produced by China Customs. We extensively cross-checked these data, and validated the approach and assumptions. We later use the same methodology for the analysis of individual bottleneck commodities.

The result of this aggregate data exercise is shown in Figure 1. Imports into China of both intermediates and capital goods according to consistent BEC4 categorization declined moderately in the nine years between 2015 and 2024. BEC4 includes many commodities in the Intermediates category (some were subsequently reclassified as capital or consumption goods in BEC5). As a result, intermediates and raw materials are predominant in China's import basket. (Consumption goods are especially small, amounting to only 1% of GDP over the entire period.) Intermediates have declined from just over 8% of GDP to just under 7%, while capital goods have declined proportionately more steeply from over 2% to about 1.5% of GDP. Reductions of this size are significant, if not overwhelmingly. We work with the simplifying assumption that reduced imports of capital goods and intermediates equate to domestic technological upgrading. This occurs when Chinese firms learn to produce substitutes for previously imported capital goods.



3. Specific Commodities Embodying Key Technologies

We next examine specific commodity imports drawn from the Chinese lists of critical bottleneck technologies. In the first round, we identified 85 eight-digit HS codes that derive from a series of articles published in *Science and Technology Daily* in 2018. These were clustered into 16 technology groups, with medicaments later added as a 17th group (Table 1; for more detail, Appendix A). For ease of understanding, these groups were then classified into four categories: semiconductor intermediates; semiconductor-related capital goods; other intermediates that embody bottleneck technologies; and other capital goods that embody bottleneck technologies. The classification into intermediates and capital goods is checked to be consistent with BEC4. The classification into semiconductor and non-semiconductor reflects the fact that integrated circuit imports—the primary category of semiconductor intermediates—are enormous, accounting for around 2% of GDP by themselves through most of this period. (As a consequence, IC imports and semiconductor intermediates are generally shown on a separate axis (usually the RHS axis) in our graphs.) Additionally, as we will demonstrate later, quantitative trends are very different for semiconductor-related aggregates than for non-semiconductor.

Table 1: Technology Groups

Sector	Category	Semiconductor-related?
1 Passive Component	Capital Goods	Semi
2 Integrated Circuits (ICs)	Intermediate	Semi
3 Silicon Processing	Capital Goods	Semi
4 Energy Equipment	Capital Goods	Other
5 Laser or Optical Measurement Devices	Capital Goods	Other
6 Lithography for Electronics	Capital Goods	Semi
7 Telecommunication Equipment	Capital Goods	Other
8 Cleanroom Process Equipment	Capital Goods	Semi
9 Fluid Control Equipment	Capital Goods	Other
10 Bearings and Alloy Steel	Intermediate	Other
11 Hot or Cold Process Equipment	Capital Goods	Semi
12 Polymers	Intermediate	Other
13 Batteries and Components	Intermediate	Other
14 Automotive and Power Systems	Intermediate	Other
15 Medical and Bio Precision Equipment	Capital Goods	Other
16 Aviation & Aerospace	Capital Goods	Other
17 Medicaments	Consumption Goods	Other

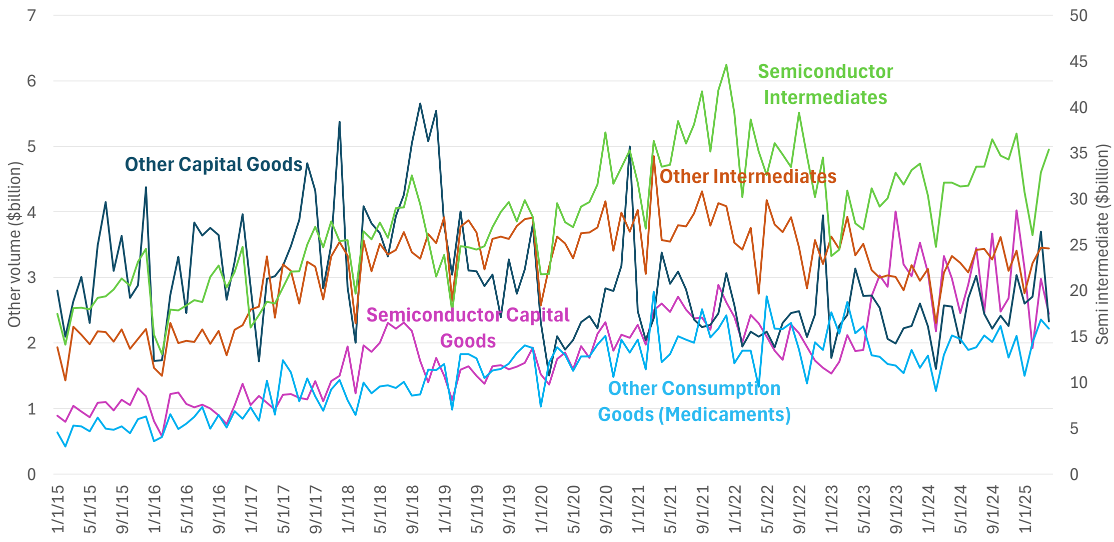
To serve as an external validation check on the analysis, and to pilot an expansion and updating of the analysis, we looked at two additional batches of "bottleneck" import commodities. "Batch 2" is a pilot sample drawn from the 2023 Green Book. This consists of nineteen eight-digit HS codes corresponding generally to advanced manufacturing technologies (Appendix A). These have not yet been integrated into the main analysis, but in general can be considered as another group of "other capital goods." The objective was to determine whether it was feasible to continuously update the analysis. In particular, China obviously seeks to continuously move the import substitution process toward more technologically advanced goods. It would be reasonable to expect a pattern in which successful substitution of one batch of imports is followed by an effort to substitute an even more sophisticated subsequent batch.

A third batch of bottleneck commodities was obtained as a side effect of the trade tensions between China and the US in early 2025. The Chinese Ministry of Commerce canvassed US-invested firms in China to determine which imports *they* purchased for which no substitutes existed, and for which the imposition of crippling retaliatory tariffs over 100% would cause significant economic hardship. The Ministry of Commerce then compiled the responses into a list of 131 commodities eligible for tariff exemption, and this list was leaked to the outside world, perhaps inadvertently, creating "Batch 3." We compared this list with our internally constructed chokepoint technology commodity candidate list. The comparison reveals that approximately three-quarters of the trade value in the exemption list overlaps with items in our chokepoint list, validating that our chokepoint commodities are still a focus of China's self-reliance industrial policy.

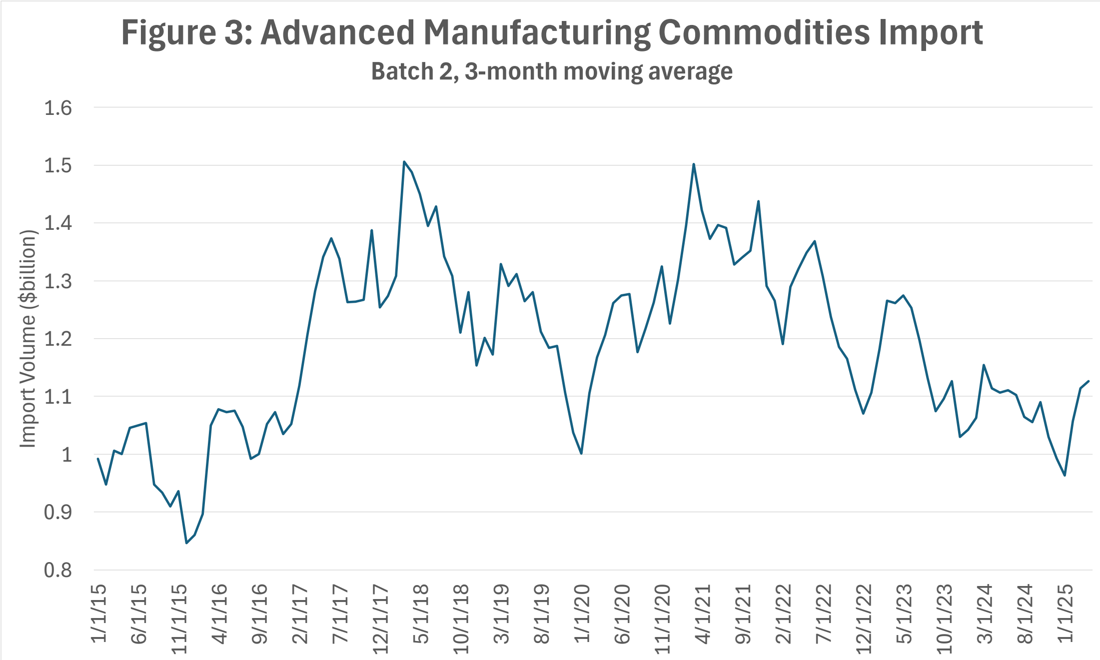
During this process, we identified medicines as an overlooked but critical chokepoint category. (The term used in the trade data is "medicament," a sub-category of pharmaceuticals that is packaged for individual use. See will use the terms "medicine" and "medicament" interchangeably.) Medicines emerged as one of the top five categories in the tariff exemption list, excluding integrated circuits. To validate their importance in industrial policy the 2023 Green Book of innovation roadmaps. This document outlines targeted innovation goals in pharmaceutical manufacturing which are far more ambitious and detailed that early volumes. This confirms that medicine technologies have become a national industrial policy priority, even as imports have grown. As a result, we added "Medicaments" as a chokepoint tech sector in our current working list.

Figure 2 shows the four categories of imports from Batch 1, the 2018 list of bottleneck technologies, plus medicines, classified to be consistent with BEC4 (and with IC imports scaled to the right-hand side axis). Both semiconductor-related aggregates show significant increases between 2015 and 2024, while both non-semiconductor aggregates show reductions. Semiconductor intermediates, dominated by ICs rose from under $20 billion per month in 2015 to a peak around $35 billion per month at the end of 2021, dropping sharply to $20 billion in late 2022 before recovering to $25-30 billion in the second half of 2024. Semiconductor capital goods have increased strongly throughout the entire period, and reached their record monthly high in December 2024, at around $4.5 billion.

Figure 2: Bottleneck Technology Imports (Monthly)



In the pilot project to identify Batch 3 (commodities from the 2023 Green Book list), we created an aggregate of 19 HS codes related to advanced manufacturing. Monthly import data from 2015 through December 2024 are shown in Figure 3. Monthly imports of this aggregate increased rapidly from 2015 through 2018, peaking at almost $1.5 billion in mid-2018, before dropping, then rebounding to almost the same level in early 2021. Since early 2021, imports in this category have steadily declined. Thus, this advanced manufacturing import pilot seems to show a pattern related to the industrial policy cycle. As this category of goods moves to the center of planners' attention, from 2016 to 2018, imports surged. The pattern is rather similar to that of the "other capital goods" included in the primary (Batch 1) analysis: imports peak in 2018 and 2021 and then begin a sustained decline.



4. Pattern and Trend Identification

To systematically analyze China's import patterns across 17 technology groups, we examined growth and volatility. We adopted a simple strategy of partitioning all seventeen groups into high and low volatility, and high or low growth. This produces the matrix below, which we interpret as follows. The three groups exhibiting high volatility and high growth are obvious candidates for policy-induced volatility ("stockpiling"). Industry-level analysis reveals substantial stockpiling activity for both integrated circuits in 2020-2021 and lithography equipment in 2023-2024. We interpret the seven groups of low volatility and high growth as continuing reliance on imported technology, which we designate formally as "No Discernable Effect" from self-reliance policies. We sometimes refer informally to these technologies as import substitution "failures," but we do not mean to imply this is a genuine economic "failure," simply that processes of technology import substitution that the Chinese government views as desirable have not occurred. By contrast, the six groups in the low volatility and low growth quadrant are interpreted as corresponding to successful technology import substitution. These groups indicate areas where the governments desired technology import substitution goals are seemingly being realized. Finally, the quadrant of low growth and high volatility has a single occupant, Aviation and Aerospace. Given the lumpy nature of aircraft purchases and the disruptions caused by COVID, it is not surprising that this category has high volatility. This group is anomalous in many respects, being also highly politicized. Does overall negative growth of imports in this sector correspond to overall successful import substitution? We suspect not, and will subject this to later external validation. Specific values for each of the 17 groups are shown in Appendix Table C1.

Matrix: Seventeen Technology Groups

	High Growth (G > 0.5)	Low Growth (G < 0.5)
High Volatility (V > 0.3)	Cleanroom Process Equipment Energy Equipment Hot or Cold Process Equipment Lithography Equipment Medicines Silicon Processing Tools	Aviation & Aerospace
Medium Volatility (0.24 ≤ V < 0.3)	Integrated Circuits (ICs) Laser/Optical Devices Medical/Biotech Equipment	Passive Components Telecom Equipment
Low Volatility (V ≤ 0.23)	Fluid Control Equipment	Automotive / Power Systems Batteries and Components Bearings and Alloy Steel Polymers

Volatility Index

The **Volatility Index (V)** captures the degree of fluctuation in monthly trade values over time. It is calculated using the **coefficient of variation (COV)**, which standardizes the standard deviation by the mean to account for scale differences between sectors.

$$Volatility\ Index_i(COV) = \frac{SD(X_i)}{Mean(X_i)}$$

Where:

- X_i is the time series of monthly trade values for sector i
- $SD(X_i)$ is the standard deviation
- $Mean(X_i)$ is the mean

This index highlights sectors with erratic or irregular trade flows, helping identify instability or speculative behaviors such as stockpiling.

Volatility Index V > 0.3 is classified as high volatility, suggesting erratic trade behavior, possibly due to policy disruptions, stockpiling, or supply chain instability. Volatility Index V < 0.3 is classified as low volatility, meaning imports are relatively stable.

Growth Index

The Growth Index is designed to reflect the direction and magnitude of long-term trends, with recent data weighted more heavily.

Calculation steps:

1. Monthly values X_{it} wered converted to growth indexes with January 2015 set to one. This is done for each sector i individually to remove scale effects.

$$X'_{it} = index(X_{it}) = \frac{x_{i,t} - x_{i,1}}{x_{i,1}}, t = 1, 2, \dots, T$$

   Where $x_{i,t}$ is the trade value of sector i at time t, and $x_{i,1}$is the trade value of sector i at the **initial** time period.

2. The weighted mean for X'_{it} was calculated on time t using weights that increase linearly with time:

$$Growth\ Index_i = \frac{\sum_{t=1}^{T} \omega_t \cdot X'_{it}}{\sum_{t=1}^{T} \omega_t}$$

   Where ω_t is a time-dependent weight, e.g., $\omega_t = t$.

This index was chosen by preference over the unweighted average monthly growth rate (which would give too much importance to the early period) and over the cumulative growth rate (which would give too much importance to the volatile final month's value). A Growth Index > 0.5 was considered to indicate a substantial shift in trade dependence. Conversely, a Growth Index <0.5 was taken to indicate slow growth or decline. Considering that GDP and domestic demand display a secular increasing trend, slow growth in a given import category indicates China may be decreasing the ratio of foreign import goods in domestic consumption, either through an intentional industrial policy or through autonomous shifts in demand.

Summarizing Trends

Based on these indices, we identified different trade patterns, and categorized each technology group into one of four trade trends (also shown in the Table C1):

1. Stockpiling or Other Policy Disturbance ("Stockpiling"): High growth (Change Index > 0.5) in imports with high volatility (Volatility Index > 0.3) → suggesting precautionary purchases in response to policy risks (e.g., semiconductors).

2. No Discernable Effect ("Failure"): High growth (Change Index > 0.5) with low volatility (Volatility Index < 0.3) → suggesting continued reliance on foreign technology without evident substitution.

3. Import Substitution ("Success"): Stable or low growth (Change Index < 0.5) with low to medium volatility (Volatility Index < 0.3) → indicates successful domestic substitution of imports.

4. Volatile Reduction of Dependence (Aviation and Aerospace only).

These classifications provide a structured way to assess China's self-reliance progress and reveal which sectors continue to face external dependencies.

Classifying Main Bottleneck Technology Import Groups

Stockpiling in Key Sectors: The Semiconductor Rush

A notable pattern emerging from the trade data is the significant increase in import volume with high volatility in several high-tech sectors, particularly:

- Cleanroom Process Equipment**.**
- Energy Equipment
- Hot or Cold Process Equipment
- Lithography for Electronics
- Silicon Processing
- Medicaments

These trends align with what has been widely recognized as a stockpiling effort in response to U.S. trade restrictions on semiconductor technology exports. The most striking example is lithography equipment, which saw an over 11-fold increase in percentage change and exhibited high volatility, underscoring the rush to secure critical manufacturing tools before restrictions fully took effect.

This stockpiling story aligns with earlier observations of a spike in semiconductor imports during 2021 - 2022, with semiconductor equipment imports peaking in 2023 and 2024. The behavior suggests that Chinese firms, recognizing the risks posed by foreign restrictions, accelerated imports of capital-intensive semiconductor manufacturing tools to hedge against future supply disruptions.

- Integrated Circuits (ICs)

The same logic applies to Medicaments, a sector traditionally excluded from core chokepoint technology discussions but now showing similar import dynamics. Trade data for medicament-related commodities reveals high volatility and substantial growth over the past several years, a signal of deliberate stockpiling. These commodities ranked among the top five by trade value in the HS8-level tariff exemption list (excluding ICs). Additionally, several of them are included in the "China Manufacturing Key Technology Innovation Roadmap (2023)" (中国制造业重点领域技术创新绿皮书, pp. 328–335), affirming their inclusion in China's broader industrial self-reliance agenda.

These findings reinforce the broader theme that while China seeks technological self-reliance, in the short term, it remains highly dependent on foreign semiconductor technology. The volatility observed in these sectors suggests that the industry is experiencing rapid shifts due to policy uncertainties and external constraints.

Tech Failure: Sectors with Persistent Foreign Dependence

Several technology groups have shown consistent import increases over time with low volatility, signaling continued dependency on foreign imports rather than successful substitution. These include:

- Laser or Optical Measurement Devices
- Medical and Bio Precision Equipment
- Fluid Control Equipment

Unlike the stockpiling behavior observed in semiconductor-related sectors, these categories exhibit steady but moderate import growth, implying that domestic alternatives have yet to emerge at scale. The low volatility in trade volumes suggests that Chinese firms continue relying on stable foreign supply chains for these technologies rather than experiencing erratic shifts due to policy-induced disruptions.

This persistent reliance is especially significant in the medical and precision bio-equipment sector, where China's attempts to develop self-sufficient production capabilities have been slow to materialize. The data suggest that despite policy directives emphasizing technological self-reliance, foreign firms remain dominant suppliers of critical precision instruments and medical equipment.

Signs of Self-Reliance Success: Declining or Stable Import Volumes

Conversely, several sectors exhibit flat or decreasing import trends with low volatility, indicating progress in reducing foreign dependence and a successful shift towards domestic alternatives. Notable among them are:

- Passive Components
- Telecommunication Equipment
- Polymers
- Automotive and Power Systems
- Batteries and Components
- Bearings and Alloy Steel

These sectors either show a decline in imports or remain stable despite increasing domestic demand, suggesting that local production capabilities have improved sufficiently to offset external reliance. The most striking example is polymers, which witnessed a significant decrease in both percentage change and absolute volume. This supports the view that China has successfully scaled up domestic polymer production, reducing its dependence on foreign suppliers.

Similarly, the flat trajectory of telecommunication equipment imports signals that China's domestic firms - particularly industry leaders like Huawei and ZTE - are increasingly capable of meeting local demand with homegrown technologies. This aligns with the broader shift toward state-backed industrial strategies emphasizing indigenous innovation.

Despite this policy attention, the medicament sector has not achieved stable domestic substitution. Approximately 75% of the import trade value in the tariff exemption list overlaps with our Candidate Chokepoint List, with medicaments displaying similar fluctuating and increasing import patterns, which supports the interpretation of stockpiling behavior. This suggests that Chinese firms are proactively building reserves of critical medicament inputs and products in anticipation of potential supply disruptions, reflecting a broader understanding of self-reliance that includes biopharmaceutical sovereignty in addition to semiconductor resilience.

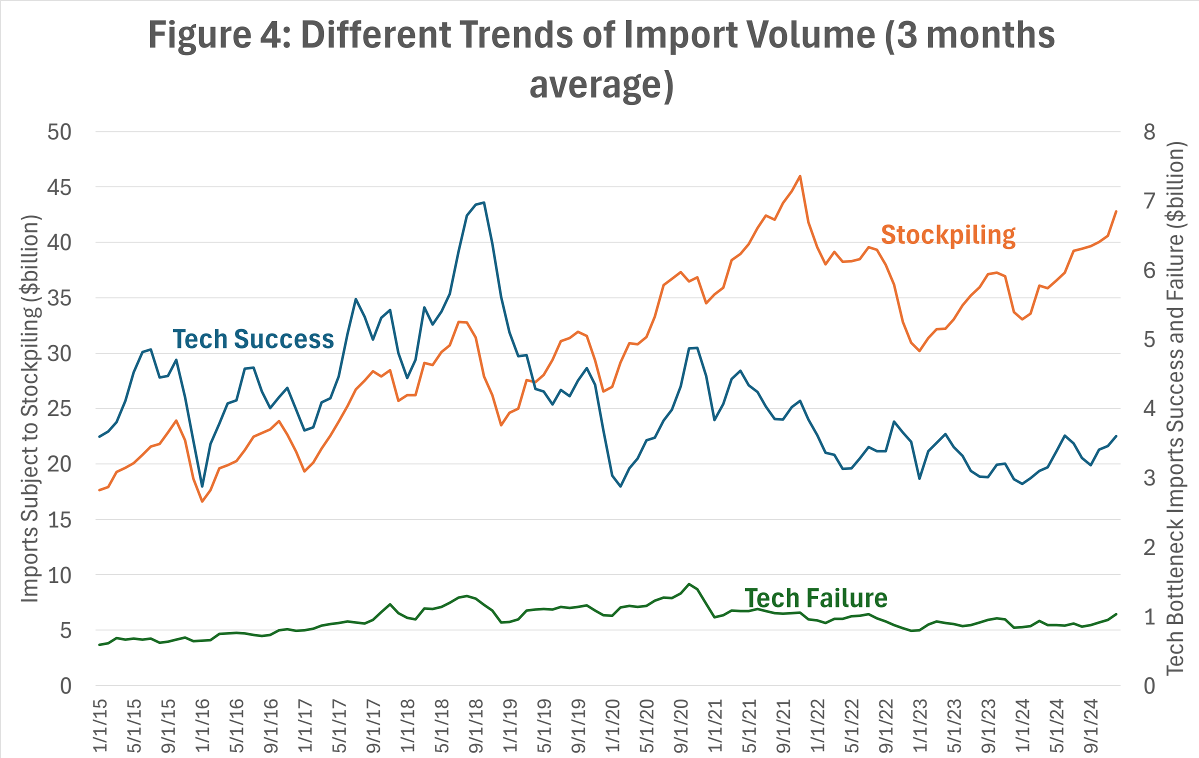
Conclusion: A Mixed Picture of Self-Reliance and External Vulnerability

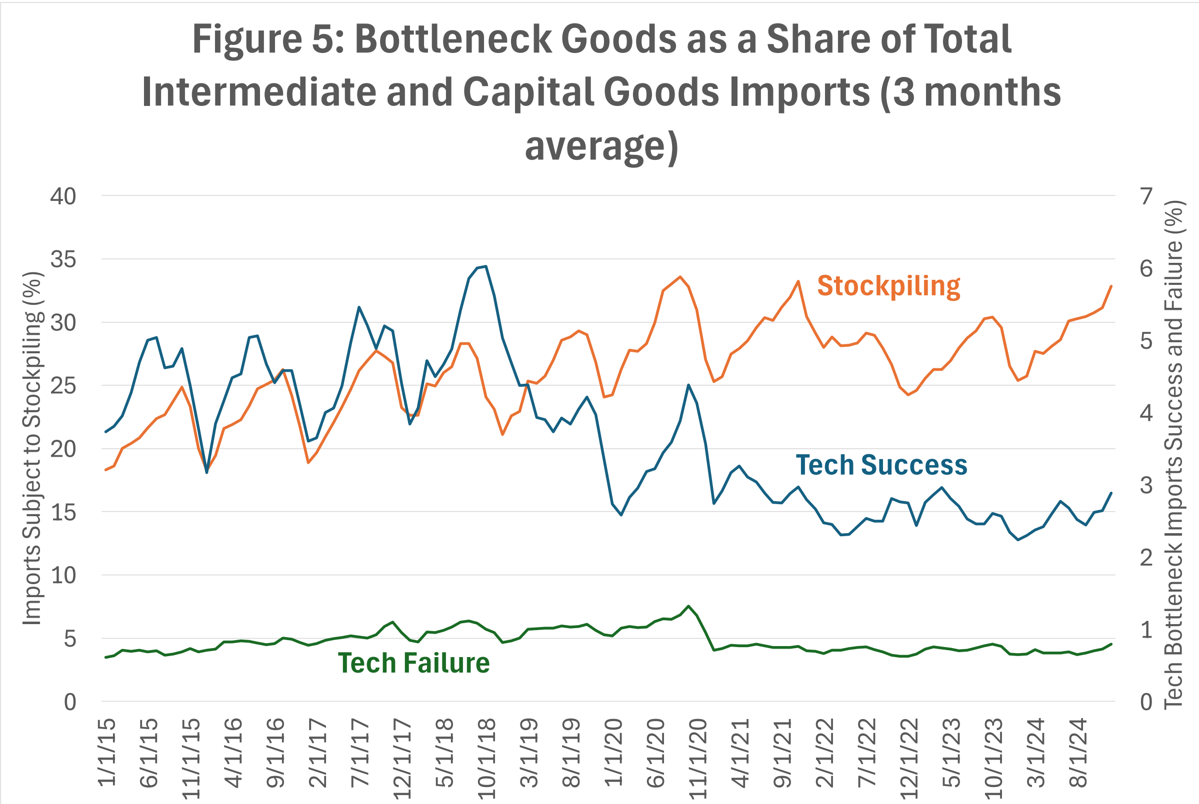
The trade pattern analysis reveals a mixed reality in China's quest for self-reliance. As the smoothed figure of normalization shows, while some technology groups show clear signs of successful substitution, others continue to rely on foreign imports, either through stockpiling strategies or stable trade patterns.

- The semiconductor sector remains highly volatile, with clear evidence of stockpiling behavior in response to trade restrictions.
- Certain high-tech equipment groups, such as medical precision instruments and advanced industrial machinery, continue to see stable foreign dependence, suggesting that self-reliance is far from complete.
- Several industrial sectors, including polymers, telecom, and power systems, show tangible progress in import substitution, indicating successful scaling up of domestic industry.
- The high degree of overlap between commodities in Batch 3 (the 2025 tariff exemption list) and our Batch 1 list of bottleneck sectors suggests a reasonably high degree of persistence of crucial bottleneck areas. This suggests that policy interventions have had some impact, but have not stabilized or created a new normal pattern of self-reliance.

In some respects, these patterns are consistent with a story in which planners try to reduce dependency, but succeed primarily in narrowing dependencies, focusing import dependence in capital goods on those more limited high-tech sectors. This is not failure, but represents some of the same ways that powerful economic forces slow down the changes that policymakers want to see, in the same way, American policymakers don't get as dramatic a decoupling as they perhaps wanted.

These findings reinforce the nuanced nature of China's industrial self-reliance efforts - progress is visible in select sectors, but critical dependencies persist in areas where foreign technology remains indispensable. This dynamic suggests that while China's long-term goal remains reducing foreign reliance, in the short term, trade volatility and strategic stockpiling will likely continue.



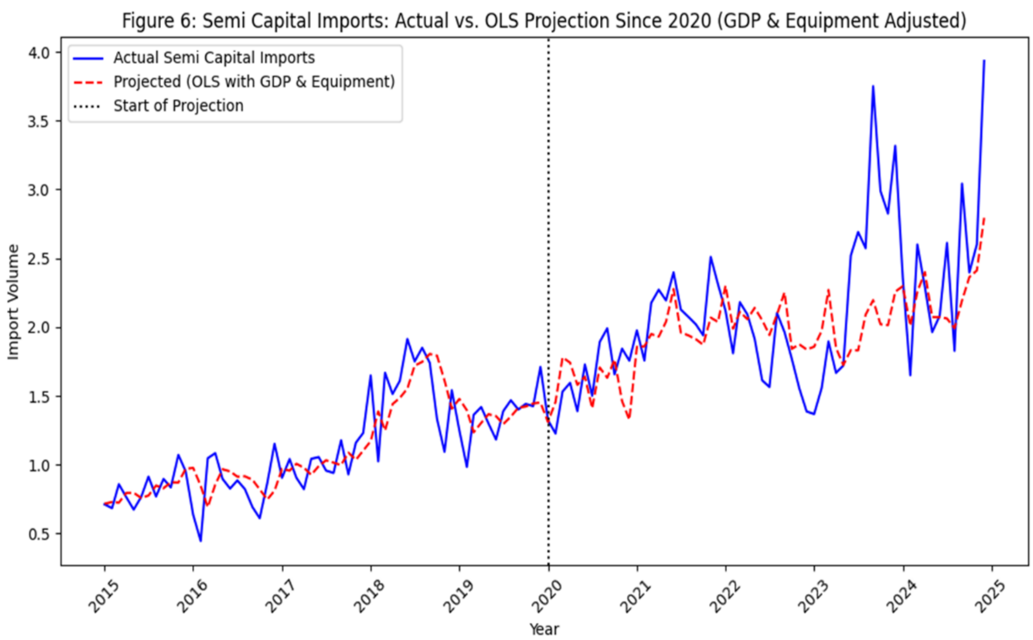


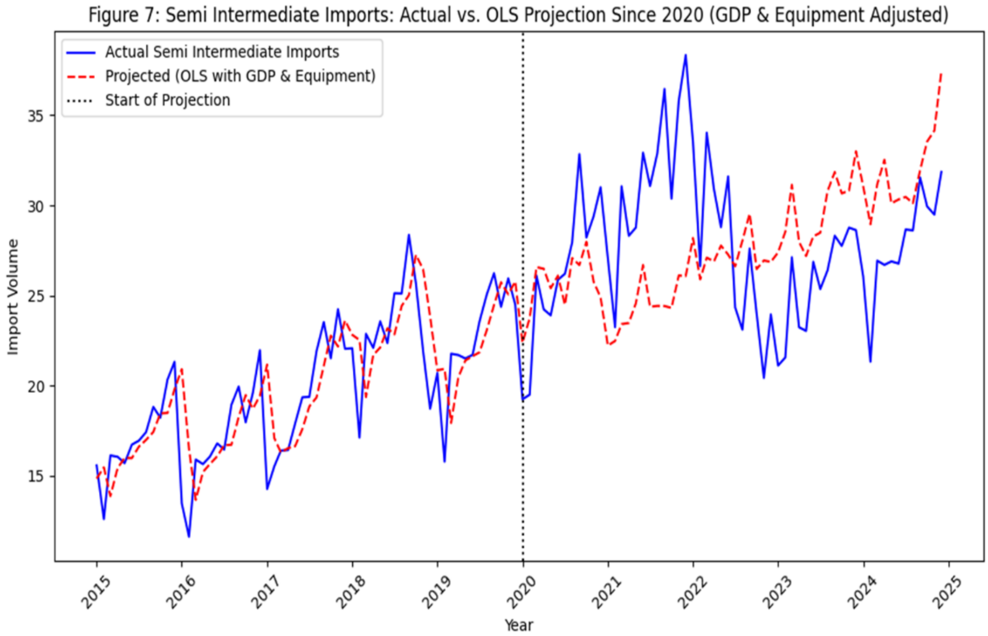
5. Magnitude of Stockpiling in Semiconductor Industry

The import patterns with respect to the semiconductor industry - as is widely recognized - reflect substantial stockpiling and precautionary purchases. This is true both for semiconductors themselves (an intermediate) and for semiconductor equipment (capital goods). Therefore, we make some very crude assumptions about the share of semiconductor imports that are precautionary, and then subtract those from the total. This gives us essentially three categories of technology-embodying imports for both intermediates and capital goods: semiconductor precautionary; semiconductor ordinary; and non-semiconductor.

Since all groups in the Stockpiling trend are semiconductor-related, to estimate semiconductor and semiconductor equipment demand in the absence of precautionary stockpiling, we use an Ordinary Least Squares (OLS) regression model based on pre-2020 import trends. The model incorporates time as an independent variable to capture underlying growth patterns, while also adjusting for macroeconomic conditions (GDP) and technological expansion ("consistently increasing" equipment-related demand trends, here we took Hot or Cold Process Equipment group; while such equipment has some use in the semiconductor industry, it is mostly used in other sectors). By estimating an OLS model for 2015-2019 data, we establish a baseline projection of what semiconductor import volumes would have been had stockpiling not occurred.

$$Import\ Volume_m = \beta_0 + \beta_1 \times Time_m + \beta_2 \times GDP_y + \beta_3 \times Equipment_m + \epsilon$$





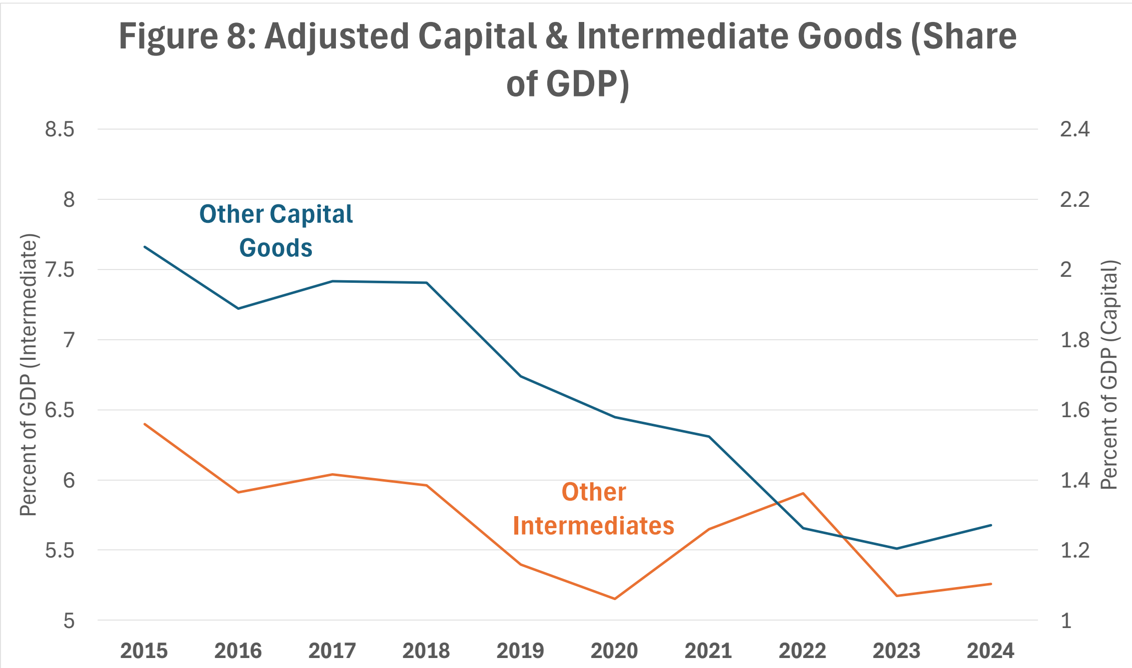
Using this projection, we compare expected and actual semiconductor capital and semiconductor intermediate goods imports from 2020 onward. The difference between these two values represents excess demand driven by precautionary stockpiling. As expected, IC imports, shown in Figure 7 show a surge of precautionary imports in 2021, extending into 2022. Semiconductor capital equipment-- much smaller than semiconductors--shows a different pattern, displayed in Figure 6. Semiconductor manufacturing equipment grows throughout the period, but after falling back slightly in 2022, growth accelerates in 20023 and 2024. This is consistent with the acceleration of China's semiconductor manufacturing push in 2023 and after.

This approach allows us to separate semiconductor imports into a precautionary stockpiling component and an ordinary demand component, enabling a clearer assessment of China's evolving dependence on foreign technology. By this rough projection, imports of integrated circuits (ICs--"semiconductor intermediates") between July 2020 and June 2022 were $124.9 billion more than projections. Subsequently, from July 2022 through December 2024, integrated circuits were $116.1 billion less than projections. Unfortunately, on the basis of this simple projection, we are unable to determine whether the shortfall in IC imports in 2022-2024 was due to running down accumulated stockpiles or was due to import substitution while maintaining high stockpiles. If it were entirely attributed to the latter, China would have substituted for 14.8% of IC imports. By an identical process of calculation, Chinese imports of semiconductor capital equipment are above projections from June 2023. In the subsequent 19 months, through December 2024, these imports are $8.85 billion (or 17.7%) above projection.

6. Adjusted Aggregate Categories

For a final step of analysis, we subtract the stockpiling categories from the aggregate import categories previously shown in Figure 1. Without the short-run impact of stockpiling, the long-run trends in both the categories become more evident. Figure 8 shows When these are excluded, from 2015 to 2024 capital goods imports (excluding semiconductor equipment) decline from 2.06% of GDP to 1.27% of GDP. This 38% decline in capital goods imports—scaled to GDP—represents a substantial change in China's economic relations with external suppliers. It should be noted that these are *not* generally sectors that are the focus of trade wars and technology embargoes, since they exclude most semiconductor sectors. However, in several important cases, the *are* sectors that have been the focus of China's recent industrial policies.

Intermediates by this calculation decline from 6.40% to 5.26%. While not nearly as striking as the decline in capital goods imports, the reduction must still be deemed significant. Again, trends are masked by the surge in IC imports for stockpiling purposes, and become more evident once that sub-category is set to one side. Finally, for both intermediates and capital goods there is a clear (but modest) increase in imports of in 2024. This only becomes apparent after semiconductors have been removed from the aggregate.



This aggregate analysis also sheds some light on China's semiconductor trade. Capital goods imports have become *more* focused on semiconductor machinery over this time period. Semiconductor capital equipment was only slightly over 4% of capital goods imports in 2015, and had risen to 11.9% of capital equipment imports by 2023. That implies that all other capital goods imports have declined from 2.1% of GDP to 1.27% in 2024, after hitting a low of 1.20% in 2023. By contrast, despite all the focus on semiconductors, China's determination to build that industry means that it has become—at least in the short run—*more* dependent on technology imports. Semiconductor-related capital goods increased from 0.09% of GDP in 2015 to 0.16% of GDP in 2023 and 0.14% in 2024, totaling $19 billion. Similarly, integrated circuits have become an even bigger share of intermediate goods imports. Imported semiconductors were 1.8% of GDP in 2015, increased to 2.1% in 2020 and 2021, and then fell back to 1.6% in 2024. That is, there is no trend towards growth or reduction. Non-semiconductor-related intermediates, by contrast, declined steadily from 6.4% in 2015 to 5.1% in 2023 and then 5.26% in 2024..

These steps show that China's progress has been especially great in non-semiconductor, and especially ordinary industrial inputs import substitution. This is important because this aspect of China's trade relations receives relatively little attention compared to the extremely high profile semiconductor sector.

7. Implications

Three important implications flow from our analysis. First, these policies are likely to be very costly for China. From an economic perspective, it is obvious that self-reliance will be costly. Science is a global public good, and international trade allows the import of the lowest cost, highest quality goods. Conversely, self-reliance implies cutting yourself off from extraordinary pockets of expertise that develop in different parts of the world. Perhaps in the long run, self-reliance can lead to more sustained growth through building robust domestic capabilities, but we should not expect it to contribute to economic growth in the short or medium run.

However, it also follows that it is extremely difficult to measure—or even understand—the short-term costs of these policies. In the first place, a large volume of resources is being invested in many different parts of the industrial economy (and some high-tech services). These "micro-sectors" are precisely those areas where China has not organically developed strong capabilities. Whether or not there is any systematic pattern to these "short boards" (as the Chinese term has it), they are certainly real. Variance in capabilities is substantial and enduring. China is thus almost certainly intentionally investing in areas where the return is low. This would be consistent with the pattern of a dramatic decline in total factor productivity growth rates in the Chinese economy after 2010, despite all the new technologies making their appearance.

Moreover, the increasing specificity of interventions implies they are more distorting at the microeconomic level. Whatever the benefits of a given Innovation Consortium, for example, it also reflects a very specific government intervention that constrains business autonomy, even as it rewards some types of behavior and penalizes other types. Since these interventions are spreading to many more corners of the economy, it is also likely that the efficiency loss from these interventions is increasing.

Second, Chinese planners display some awareness of the potential costs of this policy, and apply it in a way that allows agents to defect when the costs are too high. "Sustained pressure" is a better characterization than "command." On one side, Chinese businesses are encouraged and allowed to maintain relations with international suppliers. On the other side, Chinese firms are instructed to purchase small quantities of domestic supplied inputs, and test them out in comparison to their traditional international suppliers. Import substitution initiatives are allowed to fail. There are many micro-initiatives, so they don't all have to succeed. They can afford probabilistic success.

A contemporary example of this balance can be seen in the automotive arena. China's automobile producers are under sustained pressure to gradually eliminate foreign chips and foreign chip designers from their supply chains. However, they are not expected to do it overnight, and they can push back on requirements if there are not good domestic alternatives. But the pressure is not just wishful thinking, as it might have been in China's various industrial policies in earlier decade. There is monitoring, reporting, and specific pressure to perform. Innovation consortia are set up to provide a pathway to compliance. It is a flexible system, but also one in which pressure is real and unrelenting.

Third, and finally, China is in the anomalous position of restricting imports while simultaneously promoting exports. This may not be so evident from the standpoint of the United States. After all, China's policy direction is in some sense symmetric to that of the U.S.: both sides are committed to reducing trade dependence on the other, reducing both supply dependence and market dependence, pushing down imports as well as exports. However, this is not true for China with most of its other trade partners. The anomaly is never discussed: it is a forbidden topic, since China is "committed to an open world economic order."

China already has a huge manufactured goods trade surplus. Insufficient domestic demand is one component, but intentional industrial policy is also an important component and the commitment to the industrial policy ensures that the imbalances will persist and grow. This represents a huge geopolitical headache for China. It is experiencing increasing surpluses with many developing countries, all of which want to foster their own industries. A good example is Brazil, where leader-to-leader relations with China are extremely good, but import tariffs and other restrictions have been placed on imports of EVs from China. Brazil also illustrates the complex and rocky path likely to be experienced as Chinese firms invest underneath import barriers—in this case a big investment by BYD—only to experience additional regulatory issues and differing labor standards.

The dominance of strategic objectives in China's industrial policy implies substantial short and long-run economic costs. Because these costs are justified within China by the needs of national security, it is hard to see what benchmark can be used to determine whether the costs are excessive given then assumed goals. All we can say is that economic forces continue to drive outcomes in interaction with government policy objectives, and that China has committed itself to policies with profound, and probably profoundly negative, economic consequences.

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APPENDIX A: Commodities and HS Codes Selected for Analysis

Sector	Category	Code	Brief Label
Lithography for Electronics	semiconductor-related capital goods	84862031	Steppers for semiconductors
		84863031	Steppers for flat panels
		84862039	Photolithography equipment
		84862090	Semiconductor manufacturing equipment
Silicon Processing Equipment	semiconductor-related capital goods	84861010	Thermal processing equipment (crystal growth furnaces)
		84861020	Wafer grinders
		84861030	Wafer saws
		84861040	CMP machines or polishing equipment
		28046117	Large-diameter silicon ingots
		28046119	Medium-diameter silicon ingots
		28046120	Small-diameter silicon ingots
Integrated Circuits	semiconductor intermediates	85423100	Processors ICs
		85423111	Multi-function semiconductor / IC modules
		85423119	Processsors MCUs or SoCs
		85423190	Integrated processor ICs
		85423210	Multi-component memory ICs
		85423290	Other memory ICs
		85423300 (pre-2016)	Amplifiers
		85423310 (post-2016)	Amplifiers ICs
		85423390 (post-2016)	Other amplifier ICs
		85423200	Memories
		90318090	ICs for testing
		85423910 (post-2016)	Other multi-component ICs
		85423990 (post-2016)	Other ICs
		85423900 (pre-2016)	Other electronic ICs
Cleanroom Process Equipment	semiconductor-related capital goods	84862021	CVD machines for semiconductor Production
		84862022	PVD machines-semiconductor Production
		84863022	PVD machines for flat panels
		85433000	Specialized electrolytic equipment
Telecommunication Equipment	other capital goods	85177910 (post-2022)	Telecom switchers

Sector	Category	Code	Brief Label
		85177010	Optical / laser transceivers
		85177060 (pre-2022)	Optical / laser transceiver modules
		85177950 (post-2022)	Digital switchers
		85437092	RF / IF amplifiers
Energy Equip.	other capital goods	84118200	Large gas turbines
		84119990	Gas turbine components
Laser/Optical Measurement Devices	other capital goods	90151010 (post-2023)	Lidar
		90151000 (pre-2023)	Rangefinders
		90314990	Optical test instrument
		90132000	Non-diode lasers
Passive Compo-Nents	semiconductor-related capital goods	85322410	Multi-layer ceramic capacitors
		85331000	Fixed carbon resistors
Fluid Control Equipment	other capital goods	90269000	Flow and pressure meters
Bearings and Alloy Steel	other intermediates	84829100	Ball bearings
		84833000	Bearing assembly
		72286000	Cold-finished alloy steels
		72285000	Cold-formed alloy steel rods
Hot / Cold Process Equipment	semiconductor-related capital goods	81129930	Wrought Indium products
		70200011	Conductive glass
		84198990	Sublimators and cold traps
		84863010	Heat treatment equipment for flat panels
		84862010	Heat treatment equipment for semiconductor production
		85141910	Controlled atmosphere furnaces
		85141990	Electric resistance furnaces
		85143900	Miscellaneous furnaces
		69022000	High-alumina refractory bricks
		69029000	General purpose refractory ceramics
Polymers	other intermediaates-	39031990	General purpose polystyrene
		29025000	High impact polystyrene
		39012000	Polyethylene

Sector	Category	Code	Brief Label
		39014020	Polyethylene copolymers
Automotive and Power Systems	other capital goods	85079090	Rechargeable battery parts
		85069090	Non-rechargeable battery parts
		87089999	Auto parts
		85049090	Inverters
		85451900	Carbon electrodes
		84219190	Centrifugal and gas filters
Batteries and Components	other intermediates-	85065000	Non-rechargeable lithium batteries
		85076000	Rechargeable lithium batteries and battery packs
		39201010	Polyethylene membranes
		39202010	Polypropylene membranes
Medical and Bio Precision Equipment	other capital goods	90275000 (pre-2022)	Optical radiation instruments
		90121000	Electron microscopes
		90129000	Electron microscopes and components
		90279000	Microtomes
		90118000	High-resolution microscopes
		90221200	CT scanners
		90229090	X-ray equipment parts
Aviation and Aerospace	other capital goods	84111110	Turbofan engines
		84111190	Turbo-jets
		84111210	Turbofan engines
		84111290	Turbo-jets
		88024020	Aircraft
		88024010	Aircraft
Medicines	Other (final good) -	30049090	Therapeutic or prophylactic medicine
		30021500	Immunological products

Batch 2: 2023 Advanced Manufacturing Bottleneck Commodities

HS8 Code	Brief Label
84561100 (84561000 pre-2022)	Machine-tools operated by laser process
84799010	Assembly equipment for aerospace manufacturing
84798999	Manufacturing equipment for ships and marine engineering
84679910	High-speed, high-power electric spindles
84669390	Milling heads with direct-drive mechanisms
90262090	Pressure sensors for ultra-high-pressure applications
85158090	Welding heads for alloy friction stir applications
84775900 (84775990 pre-2022)	Heads for weaving, filament, and tape placement
84775910	3D printers
85158010	Heads for intelligent laser welding
84141000	Vacuum systems for industrial processes
84821010	Spindle bearings for high-performance machine tools
84821020	Bearings for screw pairs
84821030	Bearings for turntables
84662000	Precision guide rails and screws
85159000	Generators for high-power lasers
84669400	Molds with ultra-precision specifications
90319000	Encoders for high-precision measurements
90271000	Sensors for high-temperature zirconia oxygen measurement

APPENDIX B: Data Sources and Procedures

Introduction

This appendix details the data sources, classification methods, and calculation processes used in constructing the trade structure dataset. The initial objective of this project is to analyze trade dependency by aggregating trade data into four major categories – Capital Goods, Intermediates, Consumption Goods, and Raw Materials (referred to as “big big” categories). Inducing the “big big” classification aims to understand how China’s position in the global value chain has evolved over time and whether the overall trade structure exhibits different trends compared to specific “bottleneck” technology commodities.

BEC classifications appear to be consistent and reasonable. To be sure, the large number of goods classified as intermediates tend to dominate both imports and exports, but this is a reasonable cost to using BEC.

We take the absolute numbers of China's imports and exports as published by UN Comtrade and classified in the BEC system, and we apply to this the growth rates published by China Customs in the same BEC system. This means we use Comtrade data for the base—by dividing annual data by 12 to calculate "average monthly" values, and then apply China customs growth rates. We will do this in two steps. First, check the consistency between PAST China Customs growth rates and UN Comtrade implied growth rates; Second, calculate the monthly values for 2024, through December.

Data Sources and Classification Systems

We utilized two versions of trade classification, BEC 4 (2015 - 2023) and BEC 5 (2021 - 2023), both sourced from UN Comtrade. Trade volume data for these years were aggregated into "big big" categories using the BEC - "big big" Concordance Table. Additionally, month-to-month trade indices, which provide growth rates by BEC category, were obtained from China Customs. These indices, using the previous year's monthly average as the baseline (=100), were crucial in projecting trade volumes and tracking trade structure shifts.

However, a discrepancy arose as China Customs only reported BEC 5 growth rates for 2024, whereas previous years were reported under BEC 4. This created a data gap for producing a complete time series spanning 2015 to 2024.

Addressing Data Gaps

To estimate 2024 BEC 4 volumes based on available BEC 5 data, we analyzed the systematic discrepancies between BEC 4 and BEC 5 classifications. Using HS-BEC 4 & BEC 5 concordance tables, we identified significant reclassification patterns. Examples include:

- Wireless telephones (HS 851713) were classified as Capital in BEC 4 but reclassified as Consumption in BEC 5.
- Sauces (HS 210390) shifted from Consumption in BEC 4 to Raw in BEC 5.
- Liquefied natural gas was categorized as Intermediate in BEC 4 but as Raw in BEC 5.

These reclassifications overall accounted for over 90% of the total discrepancies between BEC 4 and BEC 5, indicating a systematic pattern that allowed us to estimate missing values with confidence.

To project 2024 trade volumes, we used the 2024 BEC 5 monthly growth rate from China Custom and the 2023 BEC 5 volumes from UN Comtrade (as the variable descirption table shows).

Variable	Description	Source
$BEC4AnnualVol_y$	China's annual trade volume by BEC 4 category (2015-2023)	UN Comtrade
$BEC5AnnualVol_y$	China's annual trade volume by BEC 5 category (2015-2023)	UN Comtrade
$MonthlyGrowthRate_{y,m}$	Month-to-month trade indicies by BEC 4 (2018-2023) or BEC 5 (2024)	China Custom

Since the growth rates reported by Customs are monthly, we used the average monthly value from the previous year to calculate each month's volume for the current year, then summed them up to obtain the annual volume:

$$BEC5\ Annual\ Vol_{2024} = \sum_{m=1}^{12} (\frac{BEC5\ Annual\ Vol_{2023}}{12} \times Monthly\ Growth\ Rate_{2024,m}/100)$$

The average residuals between BEC 4 and BEC 5 volumes from 2021 to 2023 (overlapping years) were then calculated as:

$$\overline{Residual} = \frac{\sum_{y=2021}^{3}(BEC4\ Annual\ Vol_y - BEC5\ Annual\ Vol_y)/BEC5\ Annual\ Vol_y}{3}$$

Using these residuals, we estimated 2024 BEC 4 annual volumes:

$$BEC4\ Annual\ Vol_{2024} = BEC5\ Annual\ Vol_{2024} \times \overline{Residual} + BEC5\ Annual\ Vol_{2024}$$

This process resulted in a complete 2015 - 2024 BEC 4 annual volume dataset, which was then used to compute the “big big” trade volume aggregates.

Bottleneck Technology Commodities

In addition to the broad trade structure analysis, we compiled a list of Bottleneck technology commodities and obtained their corresponding import volumes at the HS8 level for the period 2015 - 2024. These commodities were classified into four specific categories:

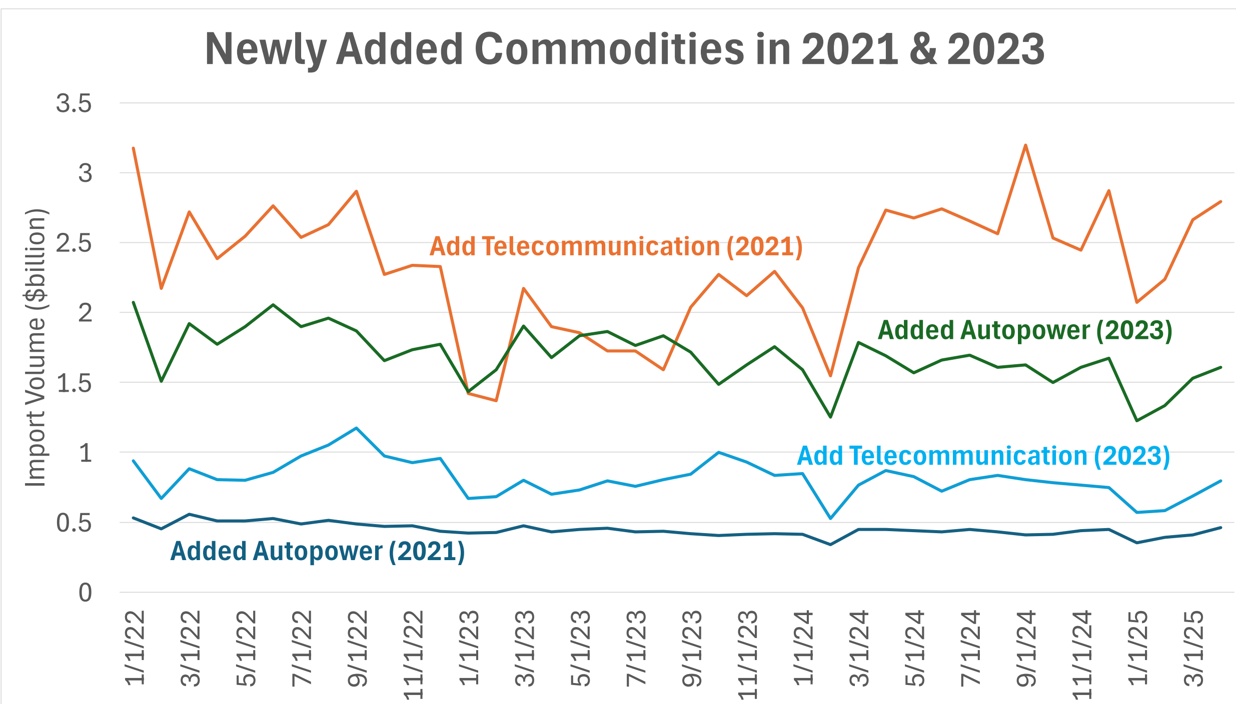
- *Semiconductor Capital:* Equipment used for semiconductor manufacturing.
- *Semiconductor Intermediate:* Integrated circuits and related semiconductor components.
- *Other Capital:* Advanced machinery and equipment used in non-semiconductor industries.
- *Other Intermediate:* Critical intermediate inputs for high-tech manufacturing beyond semiconductors.

- *Other Consumption:* Medicaments for mainly retail sale purposes

By structuring the data in this manner, we could compare the overall trade dependency and structural changes over time, especially within capital and intermediate goods. This approach also allowed us to analyze critical technological sector trends, particularly within the semiconductor industry, and assess whether the shifts in overall trade align with changes in these bottleneck technology sectors.

To refine this classification, we referred to the HS - BEC4 - “big big” concordance table to adjust and align the categorization. Import volumes of these commodities were aggregated accordingly to ensure consistency in comparison.

To track shifts in bottleneck technology commodities over time, we also incorporated newly identified candidates for *Telecommunication Equipment* and *Automotive & Power Systems* based on the China Manufacturing Greenbook (中国制造业重点领域技术创新绿皮书—技术路线图) published in 2021 and 2023. Compared to the 2018 bottleneck definition, the updated classifications reflect how China has been focusing on specific high-tech sectors like 6G, quantum technologies, and clean energy EVs. By adding these newly identified candidates to our bottleneck technology list, we monitored their import volume trends since 2022.



Validation of Calculations

To ensure accuracy, we cross-validated our estimates by comparing Comtrade and China Customs data. Using 2020 BEC 4 volume data from Comtrade as a baseline, we projected 2021 - 2023 volumes based on China Customs’ growth rates:

Calculated annual volume as the sum of monthly volume estimated from growth rate and baseline monthly volume:

$$Annual\ Vol_y = \sum_{m=1}^{12} \left(\frac{Annual\ Vol_{y-1,m}}{12} \times Monthly\ Growth\ Rate_{y,m}/100\right)$$

The projected values were then compared with Comtrade's actual 2021–2023 BEC 4 volumes. The residuals were approximately 0.3% overall (1.2% for imports and 0.6% for exports), demonstrating strong consistency between the two sources and confirming the reliability of our estimation methods.

Comparison with World Bank WITS Classification

To further validate the "big big" classifications, we compared the aggregation based on BEC 4 with the "big big" classifications provided by World Bank WITS (World Integrated Trade Solution). Significant discrepancies were observed, including:

- WITS classified liquefied natural gas as Consumption goods, while BEC 4 categorized it as Raw goods.
- WITS placed integrated circuits (ICs) under Capital goods, whereas BEC 4 classified them as Intermediate goods.
- WITS left out critical commodities such as wireless network telephone sets and solar panels by placing them in the NA category.

These inconsistencies indicated that BEC 4-based classifications provided a more logical structure aligned with global trade patterns. As a result, we chose to rely on BEC 4 as the foundation for "big big" aggregation.

Conclusion

The finalized 2015 - 2024 BEC 4 volume data, combined with the "big big" trade structure, provides the most comprehensive and accurate time series for trade dependency analysis. By addressing classification discrepancies, validating projections through historical comparisons, and cross-referencing with alternative classification frameworks, we ensured the robustness of our methodology. Our findings contribute to understanding how China's trade structure has evolved within the global value chain and highlight differences between overall trade trends and those specific to Bottleneck technology commodities, particularly in critical semiconductor-related sectors.

APPENDIX C: Commodities Driving Pattern Changes

Key Commodities Driving Import Changes

For technology groups exhibiting significant changes in trade trends, we identify a single representative commodity that is most responsible for these shifts. These commodities reflect China's evolving import needs and domestic substitution efforts.

Stockpiling Behavior (High Volatility & High Growth)

Several technology groups display a sharp increase in imports alongside high volatility, reflecting a stockpiling strategy in response to policy risks and supply chain uncertainties. The key commodities responsible for these surges include:

- Lithography for Electronics → Step-and-repeat aligners for flat panel display production (HS Code: 84862039)
  This surge aligns with China's intensified semiconductor manufacturing efforts and concerns over lithography equipment restrictions.
- Integrated Circuits (ICs) → Integrated processor ICs (HS Code: 85423190)
  China remains heavily dependent on imported high-performance processor ICs, despite growing efforts in domestic semiconductor production.
- Medicaments → Therapeutic or prophylactic medicine (HS Code: 30049090), Immunological products (HS Code: 30021500)
  Emerging sector in recent years, imports surged with high volatility, reflecting stockpiling amid reliance on foreign pharmaceutical supply and limited domestic substitution.

Continued Foreign Dependence (Low Volatility & High Growth)

Certain technology groups demonstrate steady import increases without major fluctuations, signaling a persistent reliance on foreign suppliers rather than an immediate push toward self-reliance. These key commodities include:

- Laser / Optical Measurement Devices → Non-diode lasers (HS Code: 90132000)
  Non-diode lasers play a vital role in industrial manufacturing and medical applications, with imports remaining stable and steadily rising.
- Silicon Processing → Chemical mechanical polishers (CMP) for wafer manufacturing (HS Code: 84861040)
  CMP tools are critical for semiconductor fabrication, and rising imports suggest China's continued reliance on foreign suppliers for precision processing equipment.
- Cleanroom Process Equipment → Chemical Vapor Deposition (CVD) machines for semiconductor production (HS Code: 84862021)
  The demand for CVD equipment reflects ongoing expansion in China's semiconductor fabrication plants.

- Energy Equipment → Gas turbine components (HS Code: 84119990)
  China's efforts to enhance domestic energy infrastructure rely on gas turbine components, which continue to see strong import demand.

- Hot / Cold Process Equipment → Heat treatment equipment for semiconductor production (HS Code: 84862010)
  Thermal processing equipment is essential for semiconductor manufacturing, and China has yet to develop domestic alternatives at scale.

- Medical and Bio Precision Equipment → Electron microscopes (HS Code: 90121000)
  Crucial for scientific and industrial research, import volumes of electron microscopes are increasing while domestic production capacity improves.

Self-Reliance Success Trend (Low Volatility & Low Growth)

Conversely, certain technology groups are experiencing stable or decreasing import levels, suggesting successful domestic substitution of previously imported goods. The key commodities in these sectors include:

- Polymers → High-impact polystyrene (Styrene) (HS Code: 29025000)
  A declining reliance on imported styrene suggests that China has successfully scaled domestic polymer production.

Conclusion: A Sector-Specific Approach to Understanding Self-Reliance

We gain a more precise understanding of China's trade behavior by pinpointing the specific commodities driving changes within key technology groups. The stockpiling of semiconductor-related equipment, the continued reliance on laser and heat treatment technologies, and the successful substitution of polymers and medical instruments all reflect China's evolving approach to self-reliance.

These findings suggest that while some sectors are aggressively stockpiling, others remain locked in foreign dependency, while a few have successfully transitioned to domestic alternatives. This granular commodity-level analysis enhances our ability to track and forecast China's technological self-sufficiency progress.

Table C1: Classification of 17 Technology Groups & Patterns

Sector	Volatility Index	Change Index	Trend	Pattern
Automotive and Power Systems	0.21	0.21	Low volatility, Low growth	Import Substitution
Batteries and Components	0.22	0.02	Low volatility, Low growth	Import Substitution
Bearings and Alloy Steel	0.14	0.11	Low volatility, Low growth	Import Substitution
Cleanroom Process Equipment	0.50	2.20	High volatility, High growth	Stockpiling or Other Policy Disturbance
Energy Equipment	0.57	2.14	High volatility, High growth	Stockpiling or Other Policy Disturbance
Fluid Control Equipment	0.20	0.61	Low volatility, High growth	No Discernable Effect
Hot / Cold Process Equipment	0.36	0.78	High volatility, High growth	Stockpiling or Other Policy Disturbance
Integrated Circuits	0.25	0.63	Medium volatility, High growth	Stockpiling or Other Policy Disturbance
Lasers / Optical Measurement Devices	0.27	0.62	Medium volatility, High growth	No Discernable Effect
Lithography for Electronics	0.78	2.76	High volatility, High growth	Stockpiling or Other Policy Disturbance
Medical and Bio-Precision Equipment	0.24	0.44	Medium volatility, High growth	No Discernable Effect
Medicines	0.36	1.57	High volatility, High growth	Stockpiling or Other Policy Disturbance
Passive Components	0.27	0.43	Medium volatility, Low growth	Import Substitution
Polymers	0.23	0.27	Low volatility, Low growth	Import Substitution
Silicon Processing Tools	0.49	2.94	High volatility, High growth	Stockpiling or Other Policy Disturbance
Aviation & Aerospace	0.55	-0.21	High volatility, Low growth	Import Substitution
Telecommunication Equipment	0.27	-0.01	Medium volatility, Low growth	Import Substitution