Navigating Security-driven Connectivity and Technology-driven Connectivity in International Digital Infrastructure Governance: How Network Position Shapes Submarine Cable Policy in the United States, Japan, and ASEAN [1]

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Abstract

This article explains why allied and regionally connected actors adopt divergent security strategies in submarine cable governance despite facing comparable exposure to Chinese participation across the cable value chain. It advances an interactional argument in which network position and institutional power jointly shape the feasible repertoire of security practices and their political legitimation. Hub actors with strong coercive regulatory capacity are more likely to pursue hypersecuritization, namely the explicit reclassification of cables as national security assets accompanied by routinized exclusionary review and coalition based alignment. Spoke actors with strong technocratic capacity are more likely to pursue strategic desecuritization, namely the pursuit of protection through civilian economic governance and industrial policy that emphasize resilience and competitiveness while limiting overt confrontation. Regional actors with consensus based authority and uneven capability are expected to favor strategic desecuritization through coordination, partnerships, and incremental capability building rather than binding exclusion. The analysis combines structural diagnosis and comparative process tracing. It uses revealed comparative advantage and revealed technological advantage to map capability and dependence patterns, and it traces institutionalization through legislation, regulatory design, and regional declarations. The findings show that the United States institutionalizes hypersecuritization through continuous security review and alliance coordination. Japan institutionalizes strategic desecuritization through layered economic security regulation and industrial strategy centered on diversification and resilience. ASEAN exhibits an emergent pathway of strategic desecuritization oriented toward regional resilience, repair readiness, and trusted cooperation under institutional constraints. The article contributes to debates on weaponized interdependence and securitization by demonstrating that securitization is best understood as differentiated institutionalization shaped by positional constraints, not as a uniform response to a shared threat

Keywords: Submarine Cable, Network Technology, Digital Infrastructure, Weaponized Interdependence, Strategic Desecuritization, United States, Japan, ASEAN

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1. Introduction

Submarine cables underpin the contemporary digital economy by carrying the overwhelming share of cross border data traffic and enabling financial transactions, cloud services, and artificial intelligence applications. For decades, cable governance was treated as a commercial and technical domain, managed through private consortia and routine licensing. That settlement is eroding. Intensifying strategic competition and the rising value of data have elevated cables from background infrastructure to objects of contestation in economic security and national security policy. As a result, cable governance is shifting from a logic of technology driven connectivity, which prioritizes efficiency and scale, toward a logic of security driven connectivity, which prioritizes control, resilience, and exclusion.

This divergence matters because submarine cables now sit at the infrastructural core of AI-driven digital transformation. As artificial intelligence intensive production expands, cross border data flows become more economically valuable and more politically contestable. Governance is therefore shifting from a logic of technology-driven connectivity oriented toward efficiency to a logic of security-driven connectivity oriented toward control. In that setting, deep dependence on supply chains linked to China is increasingly interpreted not as benign market integration but as a structural vulnerability that can be exploited for coercion. What once appeared as mutual prosperity is reframed through weaponized interdependence, in which states translate asymmetric network control into strategic leverage (Farrell and Newman 2019; Drezner et al. 2021).

This article develops a comparative explanation for divergent security strategies in submarine cable governance. The empirical starting point is a shared structural threat. Both the United States and Japan confront an industry in which suppliers and contractors linked to the Chinese state seek market share across manufacturing, installation, and maintenance. This participation raises credible concerns about covert access, supply chain disruption, and coercive leverage through infrastructural control. Yet the two allies have moved in opposite directions. The United States has pursued hypersecuritization by reframing cables as explicit national security assets and routinizing exclusionary review, licensing constraints, and coalition based coordination. Japan has pursued strategic desecuritization by embedding protective measures within civilian economic governance and industrial policy, emphasizing resilience, competitiveness, and route diversification while limiting overt confrontation.

The analytical leverage of the argument increases when a third case is introduced, namely the Association of Southeast Asian Nations (ASEAN). ASEAN sits at the geographic and commercial center of Indo Pacific data routes, and several member states host dense landing infrastructure. Singapore alone hosts multiple landing stations and dozens of connected cable systems, underscoring the region's role as a pivotal corridor for East Asia, Oceania, and North America. In parallel, ASEAN has begun to articulate collective priorities for cable resilience through regional digital ministerial processes. Yet ASEAN lacks unified coercive authority, and its member states exhibit uneven industrial and technological capability across cable related activities. ASEAN therefore confronts a dilemma that differs from major powers. Hypersecuritization could undermine investment and slow digital growth, while inaction would deepen dependence and expose the region to coercive leverage.

Theoretically, the article synthesizes weaponized interdependence with a practice centered understanding of securitization. Weaponized interdependence clarifies how network structure concentrates leverage at key nodes through chokepoint and visibility mechanisms. Practice oriented securitization clarifies how threats are enacted through institutionalization, including regulatory review, procurement constraints, and industrial programs, rather than only through rhetorical declarations. Building on these insights, I argue that cable security strategies are shaped by the interaction of network position and institutional power. Hub positions increase the feasibility and payoff of exclusionary governance, while spoke positions increase the costs of overt confrontation and elevate the value of resilience building. Institutional power shapes the policy instruments that actors can credibly deploy, ranging from coercive regulatory vetoes, to technocratic industrial programs, to consensus based regional coordination.

Further more the article combines structural diagnosis and process based explanation. It uses revealed comparative advantage and revealed technological advantage to map dependence and capability patterns in cable related value chains, and it traces institutionalization through policy documents, regulatory change, and cross border coordination. The contribution is threefold. First, the analysis clarifies why allied convergence is not the default outcome under shared exposure to Chinese participation in critical infrastructure markets. Second, it demonstrates how securitization unfolds through differentiated institutional pathways, producing distinct mixes of exclusion, resilience, and industrial upgrading. Third, by incorporating ASEAN, the article shows how regional actors can pursue strategic desecuritization as a rational security strategy when capabilities and

authority are uneven, thereby offering a policy relevant framework for regulators, firms, and regional coalitions navigating an increasingly securitized connectivity regime.

2. Literature Review

In light of the growing importance of submarine cables as digital infrastructure, related research has flourished in both policy and academic discourses. Studies of submarine cables span a wide range of fields, reflecting their long historical development. In the realm of international relations and security studies, many scholars have examined how control over information and communication networks has functioned as a tool of international order and 'hegemony', as well as a matter of national sovereignty (Cho, 2023; Ganz et al, 2024; Headrick, 1991; Hills, 2002; Hunt, 2021; Nickles, 2003; Ross, 2014; Smith, 2018; Starosielsk, 2015; Winkler, 2008). These works analyze the global undersea cable network as an instrument of imperial management and an arena for security competition dating back to the telegraph era.

Following the advent of fiber optic cables, the volume of information and data transmission surged, and the number of submarine cable systems multiplied for commercial reasons, leading to an emphasis on technical connectivity among states. However, with intensifying U.S.-China strategic competition and the securitization of data, a renewed great-power contest over data and communication networks has emerged. In response, researchers and policymakers have focused on how the expansion of fiber optic cables—alongside breakthroughs in transmission capacity and speed—heightens attention to data as a strategic asset, fueling supply chain competition in technology from the perspective of economic security (Ding & Dafoe, 2021; Floridi, 2020; Ganz et al., 2024; Gjesvik, 2023; Hong & Goodnight, 2020; Hummel et al., 2021; Liu, 2021; Mueller, 2020; Pohle & Thiel, 2020). Subsequently, research on the geopolitical dynamics of the internet and digital infrastructure has treated submarine cable networks as a domain of security rivalry among states (Hasler, 2019; Hong & Harwit, 2020; Shen, 2018; Winseck, 2017).

In addition, the rise of Big Tech and hyperscale companies has influenced these dynamics, magnifying the security value of submarine cable systems and prompting new lines of inquiry into how this heightened strategic value manifests (Beaumier et al., 2020; Bigo et al., 2019; Flyverbom et al., 2019). Against this backdrop, a growing body of scholarship has conceptualized and analyzed submarine cables as part of the security domain. For instance,

some studies address submarine cable systems from a maritime security perspective and regional cooperation with pointing the security gap (Bueger & Liebetrau, 2021; 2023; Davenport, 2025), while others focus on cybersecurity implications (McGeachy, 2022; Sherman, 2021) or examine the security threats posed by asymmetric interdependence in submarine cable networks (Cho, 2023; Farrell & Newman, 2023; Gjesvik, 2023). Building on these theoretical explorations, the present study defines submarine cable systems as physical infrastructure situated within the realm of maritime security and cyberspace, and treats the networks they form as complex security objects that affect the global economy and technology. In other words, in an international political context, submarine cable networks constitute more than mere infrastructure: they are critical infrastructure that raises issues of sovereignty over both cyberspace and maritime domains, as well as core infrastructures influencing economics and technology (Buzan & Waever, 2003; Bueger & Liebetrau, 2023; Cho, 2023).

Existing literature nevertheless leaves key gaps for explaining divergent strategies across the three cases and for deriving practical implications for ASEAN. In particular, Much scholarship extrapolates from major power experiences and treats securitization dynamics as broadly generalizable. This tendency obscures how network position and institutional capacity jointly shape what actors can plausibly do. The United States occupies a hub position and possesses strong coercive regulatory capacity, which expands the feasibility of exclusionary control and helps explain its movement toward hypersecuritization. Japan and ASEAN, by contrast, occupy spoke positions and face higher economic and diplomatic costs from overt exclusion, which makes alternative pathways more salient.

Moreover, the literature often assumes securitization as the default trajectory and devotes less systematic attention to desecuritization as a strategic option. This imbalance limits guidance on how protective outcomes can be achieved through calibrated governance that emphasizes resilience and capability building rather than continuous emergency framing. For ASEAN in particular, the policy relevant implication is that a Japanese style approach offers a more feasible spoke strategy, because it embeds protection within civilian economic governance and industrial policy while limiting overt confrontation.

In addition, sovereignty debates remain fragmented across strands of research. Sovereignty is frequently treated as a fixed attribute, yet in networked domains it is more accurately conceptualized as layered. Krasner foregrounds the legal and jurisdictional dimensions of sovereignty (Krasner, 1999), while DeNardis emphasizes that authority over

digital infrastructure also depends on practical capacity to shape and secure cross border flows (DeNardis, 2014). Security oriented accounts often stress strategic rivalry and exclusion, while digital sovereignty debates emphasize regulatory authority over data and infrastructure governance. Fewer studies integrate these regulatory dimensions with the capability dimension of sovereignty, namely the industrial and technological capacity to design, supply, and maintain key components and services in cable systems. This separation makes it difficult to evaluate how legal authority and capability based autonomy interact with dependence and capability gaps to shape strategic choices, especially for spoke actors.

Methodologically, ASEAN's structural position is operationalized through a joint assessment of trade competitiveness and innovation capacity across cable related value chains using RCA and RTA indices. This combined approach is consistent with prior research that deploys RCA and RTA to evaluate sectoral comparative advantage and technological positioning (Yu, 2018; Gokovali and Medettin, 2013; De Lyon et al., 2022). Treating these indicators as proxies for trade based embeddedness and innovation capacity connects sovereignty concerns to measurable patterns of dependence and capability, which then ground the analytical framework developed in the next section and the ASEAN tailored strategic desecuritization argument advanced later in the paper.

3. Theoretical Framework and Methods

3.1. Theoretical Framework

This article conceptualizes submarine cable security governance as a contest over connectivity in which states and regional actors seek to preserve the economic gains of open data flows while reducing exposure to coercion, surveillance, and disruption. The analytical framework integrates weaponized interdependence with a practice oriented understanding of securitization in order to explain why actors facing comparable structural exposure adopt divergent policy trajectories (Farrell and Newman 2019; Farrell and Newman 2023; Drezner et al. 2021; Balzacq 2019).

Weaponized interdependence identifies how asymmetric hub and spoke networks generate differential leverage. Farrell and Newman argue that actors controlling central nodes can activate chokepoint effects to restrict access to critical nodes, and can exploit panopticon effects to monitor sensitive flows and generate informational asymmetries that facilitate coercion,

especially when supported by institutional power (Farrell and Newman 2019; Farrell and Newman 2023). Submarine cables and their landing stations are therefore not only commercial assets but also potential instruments of control and visibility within global network structures. This positional logic clarifies why the United States, as a hub actor, possesses stronger incentives and opportunities to convert network centrality into exclusionary governance, while Japan and ASEAN, as spoke actors, face higher costs and tighter constraints when pursuing overt exclusion (Farrell and Newman 2019; Drezner et al. 2021).

Securitization theory clarifies how such structural incentives are translated into concrete policy practice. Classical Copenhagen School formulations emphasize a speech act through which an actor frames an issue as an existential threat to a referent object such as the state (Buzan and Wæver 2003). However, scholarship associated with the sociological turn emphasizes that securitization operates as a spectrum of practices embedded in social context, unfolding through institutional routines, regulatory instruments, and policy design rather than a single rhetorical moment (Salter 2008; Balzacq 2011; Balzacq 2019; Lupovici 2019; Piedade 2016; Sjöstedt 2017; Cho 2023). Building on this lineage, this article synthesizes the spectrum view of securitization with weaponized interdependence to show how cable security is instantiated through differentiated institutionalization conditioned by network position and institutional power.

Building on existing scholarship, this study advances a distinct contribution by synthesizing the spectrum view of securitization with the framework of weaponized interdependence. The novelty lies in applying this combined lens to digital infrastructure and specifically to submarine cable networks, where security politics is frequently enacted through technical governance and institutional design rather than dramatic public rhetoric. By moving beyond a narrow focus on speech acts, the framework highlights how securitization is instantiated through concrete institutionalization and patterned state behavior shaped by network position and institutional power.

The central implication is that comparable structural exposure does not necessarily produce policy convergence. Instead, security governance can develop along divergent pathways as actors legitimate protective measures through different mechanisms and administrative routines. This theoretical move is particularly salient in the context of deepening strategic rivalry between the United States and China. Over the past decade, Washington and Beijing have increasingly recast interdependence in global networks as a liability rather than a

benefit, intensifying fears of coercion and espionage. In the AI driven digital era, states that depend on infrastructure controlled or influenced by foreign entities may interpret vulnerability as an existential threat and respond by securitizing those dependencies. Under these conditions, the alignment of structural asymmetry and rival identity tends to accelerate the elevation of infrastructure concerns into the security agenda.

To operationalize this logic, the framework identifies four clusters of threats that map onto the two core mechanisms of weaponized interdependence, namely supply chain fragility, geographic concentration, adversary control, and erosion of data sovereignty. Two threats reflect chokepoint vulnerabilities that operate through a logic of denial.

First, supply chain vulnerability denotes dependence on foreign suppliers or components across the cable value chain, which can be exploited through espionage, embedded disruption capabilities, or the delay or denial of repairs. Second, single points of failure and geographic concentration create physical chokepoints when multiple cables converge on the same landing areas, raising the risk that a single incident severs many connections simultaneously. When these conditions prevail, risk mitigation typically requires diversification of landing sites and the construction of redundant routes in order to reduce concentration and improve continuity.

The other two threats capture panopticon vulnerabilities that operate through a logic of surveillance. Adversary influence or control reflects the concern that strategic competitors, particularly enterprises backed by the state, may gain leverage over critical cable infrastructure. This concern intersects with debates on data security and sovereignty, in which an actor that shapes data pathways may monitor, divert, or alter flows and thereby undermine a nation's autonomy and competitiveness. Digital sovereignty refers to a country's control over its own data and the critical systems that process it (Floridi 2020). Related arguments further suggest that control of data flows can be treated as functionally analogous to control of territory (Ding and Dafoe 2021).

Within this framing, submarine cables shift from a back end technical matter to a foundational element of sovereignty, implying that protecting cable systems approximates the defense of borders in the classical sense. ASEAN's position in this landscape clarifies why securitization pathways must be theorized as differentiated rather than uniform. ASEAN member states are deeply dependent on technology driven connectivity for development, yet they operate largely as spoke actors within global cable and data networks, with limited ability

to impose binding exclusionary rules at the regional level. As a result, ASEAN confronts the same threat clusters, but its feasible response set is narrower. Hypersecuritization could jeopardize investment and slow digital growth, while inaction would deepen exposure to chokepoint and panopticon risks. This structural predicament makes ASEAN a crucial comparative case for evaluating whether strategic desecuritization, modeled on the spoke strategy associated with Japan, can deliver protective outcomes through resilience, diversification, and capacity building without provoking the costs that accompany overt confrontation. These chokepoint and panopticon mechanisms are mutually reinforcing, and their interaction helps explain why hub and spoke actors institutionalize security governance differently.

Hub actors can more credibly weaponize chokepoint power by leveraging centrality and institutional authority to restrict suppliers, ownership, or routes through exclusionary policy. Spoke actors, by contrast, are more exposed to dependence and thus have stronger incentives to prioritize resilience centered governance that reduces vulnerability while limiting confrontational rhetoric that could amplify surveillance risks. This logic motivates a conceptual distinction between two securitization by action pathways.

Hypersecuritization denotes an approach in which security framing becomes explicit and exceptional interventions are normalized through aggressive public measures and routinized exclusion. Strategic desecuritization denotes an approach in which comparable protective aims are pursued through quieter institutional shifts that embed security within economic, technocratic, and industrial policy frames. The United States and Japan exemplify these contrasting pathways. The United States demonstrates hypersecuritization through highly visible measures targeting Chinese linked firms and through the normalization of exceptional intervention in cable related governance. Japan, by contrast, illustrates strategic desecuritization.

Constrained by dependence and lacking the same capacity for offensive weaponization, Tokyo advances protection through industrial policy instruments such as domestic subsidies and route diversification. This contrast shows that securitization can proceed through institutional practice even when public discourse remains comparatively restrained. Put differently, the United States tends to leverage coercive regulatory power to exclude risk, while Japan leverages industrial policy to build resilience and reduce exposure.

To examine these dynamics empirically, the study extends securitization theory beyond a binary assessment of successful speech acts. It treats securitization as observable in the systematic embedding of security logics within bureaucratic routines, regulatory architectures, and alliance arrangements. In this perspective, actors frame cable vulnerability as an existential threat that legitimates extraordinary measures such as tightened investment screening, forced vendor exclusions, and redundancy projects supported by alliances (Buzan et al. 1998; Cho 2023). The presence and consolidation of such measures constitute evidence of securitization even when leaders do not rely on dramatic rhetorical escalation. By synthesizing the technological and industrial characteristics of cable systems with the logic of weaponized interdependence, the analysis therefore evaluates how comparable threats are filtered through network position and institutional power into distinct policy responses, and it clarifies why ASEAN, as a spoke actor, has strong reasons to align with Japan's strategic desecuritization pathway rather than emulate the hub style exclusion characteristic of the United States.

3.2. Research Methodology and Analytical Approach

This study develops a mixed method research design that integrates comparative qualitative inference with quantitative measurement of industrial and technological positioning in the submarine cable ecosystem. The qualitative component establishes how security problematizations are translated into institutional arrangements, thereby revealing the pathway through which cable governance becomes securitized in practice. The quantitative component specifies the underlying material capability structure that conditions what forms of protection are feasible, sustainable, and politically credible. Read together, these two components enable an interpretation of cable security governance as an interaction between institutional choice and structural constraint rather than a direct mechanical response to threat exposure.

The comparative design is anchored in deliberate case selection. The United States and Japan are chosen through a most similar systems logic (Blatter and Haverland 2014; King et al. 1994). Both are advanced industrial democracies embedded within the same alliance architecture and confronted by a common external challenge, namely the expanding influence of China across critical technology sectors and infrastructure adjacent markets. Yet they differ in political economic structure and in the composition of state capacity relevant to cable governance. This controlled contrast is analytically useful because it helps isolate how

domestic institutional repertoires and policy instruments shape divergent securitization pathways under broadly comparable external pressures.

To strengthen external validity and to derive policy relevant implications for regional actors, the study incorporates ASEAN as a theoretically motivated extension case. ASEAN largely occupies a spoke position in global cable governance while simultaneously hosting strategically consequential landing hubs. Its regional authority is coordinative and consensus based, and relevant capabilities are uneven across member states. Including ASEAN therefore allows the analysis to examine whether the theoretical expectations developed for spoke actors travel to a regional cooperative body that cannot easily deploy binding exclusion. It also clarifies why a Japan aligned strategic desecuritization pathway is more plausible for ASEAN than emulation of the hub oriented exclusionary approach associated with the United States.

3.2.1. Qualitative Comparative Case Study Approach

The qualitative component adopts a comparative case study strategy centered on within case process tracing. For the United States and Japan, the analysis reconstructs the evolution of submarine cable security governance from the middle of the 2010s to the middle of the 2020s. The objective is to identify when and how cable issues were elevated into the security domain through institutional consolidation rather than rhetorical escalation alone. For the United States, a critical inflection is the formalization of an interagency review architecture for submarine cable licensing in 2020. For Japan, a parallel inflection is the enactment of the Economic Security Promotion Act in 2022, which established a governance foundation for protecting critical infrastructure and for advancing resilience oriented measures.

For ASEAN, the analysis traces how cable vulnerability was translated into a regional agenda under consensus based authority, and how member state heterogeneity shaped the limits of collective action and pushed governance toward coordination, partnership, and incremental capability building. Process tracing is complemented by structured content analysis of official policy documents, legislative texts, regulatory decisions, public statements, and documented institutionalization procedures. The coding strategy operationalizes securitization as policy practice. Securitization is coded when governments implement extraordinary measures and embed them into routinized governance, including tightened investment screening, vendor restrictions, licensing conditions, redundancy and diversification programs, and institutional designs that normalize ongoing review (Buzan et al. 1998; Cho 2023). This practice oriented

approach captures securitization by action even in contexts where explicit public discourse is limited or strategically restrained.

3.2.2. Quantitative Analysis Using Revealed Comparative Advantage and Revealed Technological Advantage

The RCA is an index used in international economics to quantify a country's relative advantage or disadvantage in a specific category of goods, as evident from trade data. This index is computed by standardizing a nation's sectoral export share against the corresponding global market share for that sector. The resulting metric provides insight into whether a country exhibits comparative advantage in a particular industry while facilitating cross-national and cross-sectoral comparisons. Drawing on Ricardo's theory of comparative advantage, the framework suggests that sectors demonstrating superior comparative advantage relative to other nations warrant political support for specialization through strategic allocation of production factors, given their competitive positioning. Within this Ricardian framework, elevated RCA values signal enhanced industrial competitiveness in global markets. An RCA index greater than 1 indicates that a country has a comparative advantage in the corresponding industry, and an index less than 1 indicates a comparative disadvantage.

To complement process evidence with a structural capability diagnosis, the study employs revealed competitiveness indicators that approximate trade embeddedness and innovation capacity in the submarine cable ecosystem. Revealed comparative advantage measures whether a country's export specialization in a given sector exceeds the corresponding global benchmark. A value above 1 indicates comparative advantage, while a value below 1 indicates comparative disadvantage. The RCA formulation is expressed as

$$RCA_{c,i,t} = \frac{EX_{c,i,t} / \sum_i EX_{c,i,t}}{\sum_c EX_{c,i,t} / \sum_c \sum_i EX_{c,i,t}} \quad (1)$$

Where *EX* denotes export value, *c* represents country, *i* is industry, and *t* is year. Export data was constructed through the World Bank World Integrated Trade Solution (WITS) website, where UN Comtrade data can be downloaded. I constructed a dataset of trade flows for products related to the submarine cable industry covering the years 2019-2023. Export and import values were obtained primarily from the UN Comtrade database which was accessed via the WITS interface of the World Bank and the database of the Korea International Trade Association (KITA), supplemented by national trade statistics. For instance, 2023 data for Korea which

were not yet in UN Comtrade at the time of analysis were taken from KITA.

A critical step is defining which products constitute the industry for submarine cable networks. This study represents one of the pioneering attempts to quantitatively map the industrial competitiveness of this specific sector by aggregating relevant Harmonized System (HS) codes. In my analysis, I include a range of goods spanning from actual fiber-optic cables to specialized equipment used in laying and maintaining undersea cables. The industry i is defined by the following industrial classifications listed in Table 1.

Table 1. Harmonized System (HS) Classification List for the Subsea Cable Industry

HS Code	Description
8430.69	Other tamping or compacting machines
8479.89	Other machines of a kind used for a particular purpose
8517.62	Machines for receiving, converting, transmitting or reproducing
8544.6	Other electric conductors, for a voltage exceeding 1,000 V
8544.7	Optical fiber cables
8905.9	Other special-purpose vessels
9001.1	Optical fibers, optical fiber bundles, and cables
9015.8	Other surveying, hydrographic, oceanographic, or meteorological instruments

Source: Author's calculation based on UN Comtrade and KITA (2023), and based on Cho (2026)

Because submarine cable security vulnerabilities are distributed across the lifecycle, industrial competitiveness must be approximated at the ecosystem level rather than through a single product line. Accordingly, the study aggregates a defined set of Harmonized System codes that correspond to cable products, manufacturing inputs, and specialized equipment for installation and maintenance. This approach necessarily relies on broad proxies, since some HS categories include both terrestrial and submarine items. Nevertheless, the composite measure is analytically appropriate for the present purpose because it captures the material footprint relevant to sustaining the end to end lifecycle of cable networks

Furthermore, Revealed Technological Advantage (RTA) index can be defined by the relative proportion of intellectual property rights, such as patents, utility models, and design rights, obtained post facto as a result of technological development. Innovation capacity is operationalized through revealed technological advantage. The OECD defines the RTA index as the share of an economy's patents in a specific technology relative to the share of total patents owned (OECD 2015). Analogous to

RCA, a value above 1 indicates relative technological advantage, and a value below 1 indicates relative disadvantage. This study adopts a patent stock approach using USPTO based data following Jeong and Yu (2025), reflecting that patents function as technology assets over their effective term rather than as one year flow indicators. The RTA index is calculation refer in the appendix.

The mixed method design links structural diagnosis to institutional pathway identification. RCA and RTA provide a capability map that clarifies where dependence is likely to translate into vulnerability and where resilience and upgrading strategies are materially plausible. Process tracing then specifies how these structural conditions are filtered through network position and institutional power to produce either hypersecuritization or strategic desecuritization. This integration strengthens inference by aligning policy practice with measurable constraints, and it supports the comparative claim that hub actors can institutionalize exclusion more readily, whereas spoke actors, including Japan and ASEAN, are structurally incentivized to institutionalize protection through resilience, diversification, and capability upgrading rather than through sustained overt exclusion.

4. Empirical Analysis of Submarine Cable Industry Competitiveness

This chapter establishes the empirical foundation for explaining why the United States, Japan, and ASEAN exhibit differentiated approaches to submarine cable security governance. It first maps the material landscape of the submarine cable ecosystem using trade based indicators of competitiveness and dependence. It then integrates these quantitative patterns with qualitative evidence on policy evolution to show how network position and supply chain vulnerability are filtered into distinct governance choices. The analytic purpose is not to treat competitiveness as an end in itself, but to identify the structural constraints and leverage points that shape which policy pathway becomes feasible and sustainable.

4.1. Global Export-Import Dependency and RCA Analysis

To identify competitiveness and strategic vulnerability, the analysis examines global trade in submarine cable related goods from 2019 to 2023. The trade data reveal a highly asymmetric production and consumption structure that carries clear geopolitical implications. Table 2 summarizes cumulative exports and imports among key economies during this period and highlights the concentration of manufacturing capacity and demand.

Table 2. Country-level Export and Import Shares for Submarine Cable Industry

Rank	Export			Import		
1	**CHN**	303.2	25.2%	**USA**	271.1	20.6%
2	DEU	89.2	7.4%	NLD	82.2	6.3%
3	NLD	83.2	6.9%	DEU	77.0	5.9%
4	HKG	79.0	6.6%	**CHN**	75.1	5.7%
5	MEX	65.2	5.4%	HKG	55.0	4.2%
6	**USA**	62.3	5.2%	MEX	50.1	3.8%
7	VNM	46.1	3.8%	**GBR**	50.1	3.8%
8	OAS	39.4	3.3%	**JPN**	41.3	3.1%
9	**KOR**	36.0	3.0%	IND	40.1	3.0%
10	SGP	34.8	2.9%	FRA	35.1	2.7%
11	**JPN**	32.5	2.7%	CAN	31.9	2.4%
12	CZE	29.3	2.4%	SGP	31.7	2.4%
13	MYS	29.0	2.4%	AUS	25.1	1.9%
14	ITA	22.0	1.8%	CZE	24.7	1.9%
15	**GBR**	21.8	1.8%	ITA	23.2	1.8%
16	IND	21.1	1.8%	ARE	23.0	1.7%
17	FRA	19.1	1.6%	**KOR**	22.4	1.7%
18	POL	18.9	1.6%	POL	17.5	1.3%
19	THA	17.7	1.5%	SWE	16.0	1.2%
20	SWE	16.4	1.4%	BRA	14.9	1.1%

Note: Aggregated 8 HS Codes, 2019-2023, Cumulative; Unit: Billion USD
Source: Author's calculation based on UN Comtrade and KITA (2023), and based on Cho (2026)

The first pattern is China's dominance as the primary exporter. Over the five year period, China records cumulative exports of roughly 303.2 billion US dollars, representing about 25.2 percent of global exports. China's imports are far smaller at approximately 75.1 billion US dollars, or about 5.7 percent of global imports. This combination produces a large surplus that is consistent with China's position as a manufacturing center for cable related equipment and components. From the perspective of vulnerability, this concentration implies that many countries face a single point dependence risk, since disruptions in China's production capacity or restrictions arising from geopolitical conflict could cascade into delays and shortages across the broader ecosystem.

The second pattern is the United States' position as the largest importer. From 2019 to 2023, the United States imports approximately 271.1 billion US dollars in cable related goods, which corresponds to about 20.6 percent of global imports. By contrast, its cumulative exports

are substantially smaller at roughly 62.3 billion US dollars, or about 5.2 percent of global exports. This imbalance indicates that the United States occupies a consumption heavy position in the ecosystem and relies on foreign suppliers for a significant share of hardware and related inputs. Even after policy efforts aimed at diversification, the data continue to reflect China's central role in the supply structure serving the United States, underscoring the practical difficulty of reducing dependence in specialized and globally integrated manufacturing sectors.

Taken together, the trade landscape depicts China as a production hub, the United States as a principal consumer, and other advanced economies such as Japan, the Republic of Korea, and the United Kingdom as comparatively smaller actors in aggregate trade shares. This configuration matters analytically because it aligns with the structural conditions under which economic interdependence can become a security liability. When production is concentrated and geopolitical relations worsen, dependence on the manufacturing hub is more likely to be reinterpreted as vulnerability. This chapter uses the trade diagnosis as the baseline for evaluating how the United States and Japan translated similar concerns about China's growing role into different governance responses, as further detailed in the appendix.

ASEAN enters this empirical landscape in a distinctive way. Several ASEAN members appear as meaningful exporters or importers in the aggregated trade picture, which indicates participation in the ecosystem even in the absence of consolidated regional dominance. Vietnam, for example, holds a nontrivial export share in the period, while Singapore and Malaysia also appear among notable exporters. On the import side, Singapore registers a substantial share, reflecting its role as a logistics and connectivity node. This pattern suggests that ASEAN's structural condition is not one of pure marginality. Rather, it is a condition of uneven participation across member states, shaped by the region's role as a downstream user of cable infrastructure, a host of landing points, and a selective contributor to manufacturing and equipment trade. This internal dispersion matters for governance because it constrains the extent to which ASEAN can adopt binding regional rules and pushes the region toward coordination and resilience building that can be layered onto existing national strategies.

4.2. RCA Analysis Results

This analysis presents the results of the empirical analysis on the trade competitiveness and industrial characteristics of the submarine cable industry in US, Japan, and China, utilizing their RCA Index from 2019 to 2023.

Table 3. RCA Index in 2023

		USA	China	Japan
	Aggregate	**0.67**	**1.35**	**0.62**
HS Code	843069	0.97	0.96	0.54
	847989	0.74	0.81	1.99
	851762	0.58	1.61	0.18
	854460	0.81	1.08	0.21
	854470	1.49	1.56	0.83
	890590	0.05	1.12	0.14
	900110	1.43	1.57	2.37
	901580	1.97	0.69	0.36

Source: Author's calculation based on UN Comtrade and KITA (2023), and based on Cho (2026)

able 3 reports RCA values in 2023 for the United States, China, and Japan. China records the highest aggregate RCA, approximately 1.35, indicating revealed comparative advantage in the cable ecosystem. This confirms that China's export prominence reflects sectoral specialization, consistent with sustained capacity expansion and the global activity of Chinese firms in cable related projects and technologies. by contrast, both the United States and Japan record aggregate RCA values below 1.0 in 2023, indicating revealed comparative disadvantage and continued reliance on imports across relevant product categories. This similarity is analytically important because it establishes a shared material constraint. Both countries treat cable systems as strategically vital, yet neither displays comprehensive export specialization in the overall ecosystem.

Disaggregated results nevertheless identify vulnerabilities that illuminate policy choice. Japan's RCA value in special purpose vessels is especially low, at 0.14. This category is consequential because specialized vessels are necessary for installation, maintenance, and rapid repair. Since cable disruptions require time sensitive response and repair capacity is difficult to substitute, reliance on foreign flagged or foreign operated vessels can become a chokepoint risk in resilience planning. This quantitative vulnerability aligns with Japan's subsequent policy shift toward subsidizing domestic capacity in cable ship construction and related resilience measures, announced in 2023 (METI 2023; MIC 2023). The data thus support the claim that Japan's strategic indispensability agenda is anchored in identifiable deficiencies in specific segments of the value chain.

For ASEAN, the RCA logic reinforces a different but related implication. Because ASEAN's trade participation is dispersed across member states and concentrated in selected categories, the region's primary challenge is not simply the level of competitiveness but the fragmentation of capability. This structure limits the feasibility of a unified exclusionary strategy and increases the importance of cooperative mechanisms that convert selective strengths into region wide resilience. In practical terms, this points toward a Japan aligned pathway for ASEAN, one that prioritizes diversification, repair readiness, and coordinated capacity upgrading while maintaining openness that remains essential for investment and digital development. Overall, the combined trade share and RCA evidence establishes a material backdrop of supply chain asymmetry and selective vulnerability. Washington and Tokyo confront similar concerns about China's role in the supply structure, yet their responses diverge. The next section shows how the United States institutionalized a more exclusion oriented securitization trajectory through investment screening and supplier restrictions, while Japan pursued a more calibrated pathway that embedded protection within industrial policy and resilience building. ASEAN's position, as a spoke regional actor with uneven capabilities and consensus based authority, further clarifies why strategic desecuritization through coordination and capability building is the most plausible governance direction in the regional context.

4.3. RTA Analysis Results

The revealed technological advantage (RTA) analysis demonstrates that ASEAN's aggregate technological position within the subsea cable ecosystem remains below the established global threshold. With a regional RTA total of 0.509, ASEAN exhibits patent-based technological specialization across selected cable-related International Patent Classification (IPC) classes that has not yet achieved consolidation. Nevertheless, the data reveal substantial intra-regional variation of considerable strategic significance. Thailand registers an RTA total of 1.343 and demonstrates particularly robust performance in specialized vessel-related categories, whereas the Philippines exhibits notable strength in optical fiber cable-related classifications, and Singapore displays moderate competencies across multiple ship and optical-related domains. This distribution pattern indicates that ASEAN possesses substantive but heterogeneously distributed capabilities, characterized by pockets of advancement alongside significant technological deficits. The policy implication derived from this

assessment is that ASEAN's strategic baseline reflects not an absence of technological capacity but rather a fragmented capability architecture requiring coordinated regional integration to consolidate niche specializations, enhance collective capacity, and translate selective strengths into systemic resilience across the submarine cable lifecycle.

Comparative assessment with the United States and Japan elucidates the structural plausibility of divergent governance trajectories for hub and spoke actors. The United States registers an RTA total of 1.20 and exhibits broadly distributed technological advantages across multiple cable-relevant categories, a profile consonant with hub actor characteristics that enable more credible institutionalization of exclusionary regulatory mechanisms and substantive influence over governance architectures. Japan, conversely, records an RTA total of 0.53 yet demonstrates concentrated competencies in discrete domains including hydrographic surveying and cable installation-related classifications, signaling a strategically focused technological portfolio rather than comprehensive sectoral dominance. This pattern corresponds precisely with the theoretical expectations for spoke actors that secure protective outcomes through selective capability development, strategic diversification, and resilience-centered governance frameworks rather than through sustained exclusionary interventions. For ASEAN, which occupies a comparable spoke position and confronts heterogeneous capability distribution across member states, the empirical evidence suggests alignment with a Japan-modeled strategic pathway that one that prioritizes regional resilience enhancement, repair capacity readiness, route diversification initiatives, and coordinated technological upgrading, while eschewing hub-style approaches predicated upon the institutional leverage and comprehensive technological breadth reflected in the United States profile.

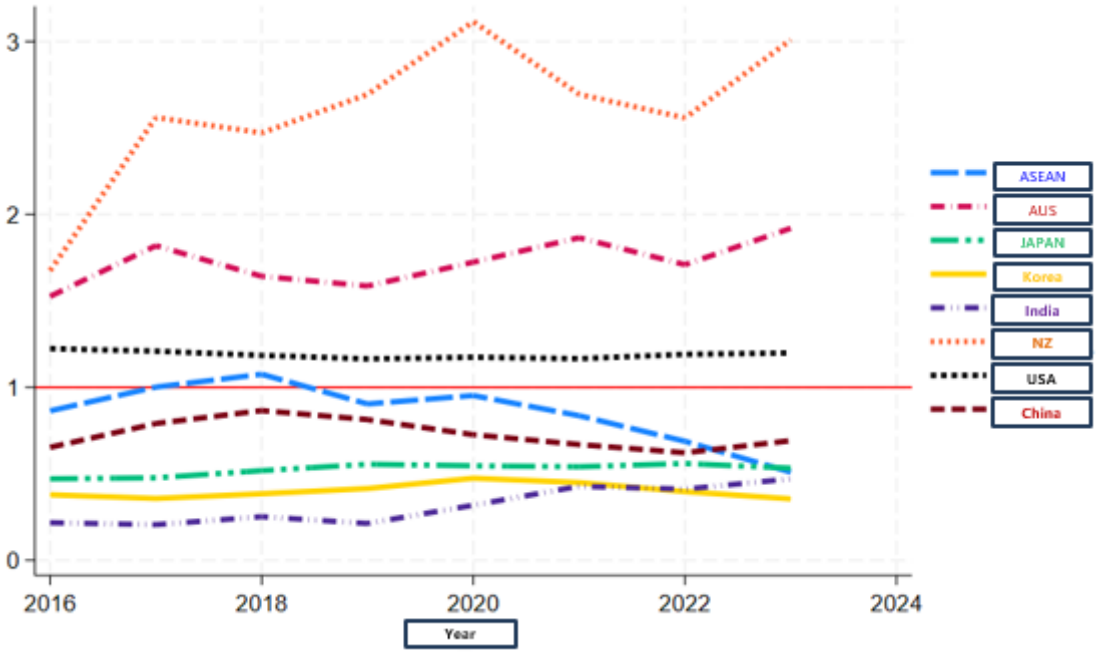

Figure 1: RTA Results

4.4. Case Study

This section analyzes how the United States, Japan, and ASEAN responded to a shared material backdrop of vulnerability in submarine cable value chains. Across the three cases, concerns about covert access, supply chain disruption, and coercive leverage are rooted in the structure of the industry and in the strategic consequences of concentrated network control. Yet the governance pathways diverge. The United States pursues hypersecuritization through coercive regulation and alliance coordination. Japan adopts strategic desecuritization by embedding protection within civilian economic governance and industrial policy. ASEAN pursues an emerging form of strategic desecuritization oriented toward coordinated resilience and capability building under consensus based regional constraints.

4.3.1 United States

In the United States, policymakers recast submarine cables from commercial infrastructure into securitized assets that require continuous review and exclusionary control. The core threat narrative asserts that Chinese linked firms could embed hidden functions in cable systems, exploit landing stations for intelligence collection, or gain leverage through installation and maintenance contracts. Once this framing took hold, the United States translated it into a

durable legal and bureaucratic architecture that normalizes exceptional scrutiny.

The first inflection point was the turn toward supply chain emergency governance. Executive Order 13873 declared foreign influence over information and communications technology supply chains a national emergency and authorized regulators to deny or condition projects deemed to pose undue risk. This move created an umbrella justification under which cable related controls could be expanded beyond isolated licensing disputes and into a broader architecture of economic security.

The second inflection point was the institutionalization of routine security review. Executive Order 13913 formalized the Committee for the Assessment of Foreign Participation in the United States Telecommunications Services Sector, widely known as Team Telecom, and strengthened its mandate to review licenses and impose mitigation agreements. This institutionalization converted an episodic security function into a routine governance mechanism, thereby lowering the political cost of repeated exclusionary outcomes. The third inflection point was the consolidation of vendor exclusion through precedent, procurement controls, and diplomatic coordination. Procurement restrictions narrowed the set of suppliers treated as trusted for government systems.

In addition the Clean Network initiative extended the logic of trusted vendors to the broader digital backbone and articulated a Clean Cable pillar that sought to align allied choices regarding subsea infrastructure. In parallel, the Partnership for Cable Connectivity and Resilience and related coalition building efforts framed cable governance as a shared strategic project, thereby amplifying the external effects of domestic exclusion through standards, financing, and coordination. By the middle of the 2020s, this trajectory matured into legislative consolidation.

The Strategic Subsea Cables Act of 2025 mandates strategic coordination for the security, installation, and maintenance of global submarine cables and directs expanded international engagement on cable security and resilience. In theoretical terms, the United States case illustrates how a hub position and high coercive regulatory capacity facilitate hypersecuritization through institutional lock in, whereby exceptional review becomes routine governance and exclusion is sustained through administrative process and coalition reinforcement.

This trajectory toward institutionalized cable security reached a heightened level of

consolidation in November 2025 with the bipartisan introduction of the Strategic Subsea Cables Act of 2025 (S.3249) by Senators Jeanne Shaheen and John Barrasso, which mandates strategic coordination for the security, installation, and maintenance of global submarine cables and directs expanded international engagement on cable security and resilience through bodies such as the International Cable Protection Committee. In theoretical terms, the United States case demonstrates how a hub position combined with high coercive regulatory capacity facilitates hypersecuritization through institutional lock in, in which exceptional review is routinized as ordinary governance and exclusion is sustained through administrative process and coalition reinforcement. Through executive orders, regulatory directives, and legislative mandates, Washington constructed a protective perimeter around undersea data highways that effectively blacklisted selected suppliers and entrenched exclusionary norms across allied networks, illustrating the dynamic in which emergency rules migrate into routine governance (Lupovici 2019). This normalization is further reflected in Pentagon memoranda requiring defense contracts to certify cable provenance (US Department of Defense 2022). Although such a hypersecuritized pathway can raise costs and contribute to internet bifurcation by restricting access to the lowest cost supplier, policymakers in the United States appear willing to accept these trade offs in order to preclude adversaries from weaponizing interdependence.

4.3.2 Japan

Japan confronts similar concerns about Chinese participation in the cable industry, but it faces different constraints and opportunities. Japan relies on open connectivity for economic growth and operates from a spoke position that limits the feasibility of broad exclusion without incurring high economic and diplomatic costs. Japan therefore constructs security through layered civilian institutionalization and industrial capacity building.

The first layer is risk management through investment and technology screening. Revisions to the Foreign Exchange and Foreign Trade Act strengthened screening of inward investment and controls over sensitive technology transfers in critical sectors including telecommunications and data infrastructure. Unlike the United States model that relies on security driven license vetoes, the Japanese approach is administered through civilian ministries and framed as safeguarding the conditions for stable growth.

The second layer is the Economic Security Promotion Act of 2022, which designates

undersea cables as specified critical facilities. Implementation emphasizes continuity planning, diversification of inputs, and resilience measures rather than nationality based exclusion. This approach advances protective aims while maintaining civilian legitimacy and avoiding overt escalation that could endanger Japan's wider position in regional production networks.

The third layer is an industrial policy turn that treats cables and data infrastructure as engines of competitiveness. In the Grand Design and Action Plan 2024 revised version, the government positions data centers and submarine cables as strategic sectors and sets a goal to make Japan a hub for data flows by 2028 through route diversification. This framing links security to economic upgrading and directs attention to bottlenecks such as maintenance capacity, repair readiness, and route redundancy. Japan therefore illustrates strategic desecuritization as a spectrum of practices in which security outcomes are pursued through technocratic and economic frames, and protective measures are embedded within civilian governance and industrial policy rather than foregrounded as confrontation.

Strategic desecuritization can be understood as a sophisticated repertoire of practices through which a state attains functional security objectives by working within technocratic and economic frames rather than relying on overt adversarial discourse. In contrast to the United States pathway of hypersecuritization, which centers on regulatory exclusion and the construction of a restrictive governance perimeter to block untrusted vendors, Japan demonstrates that security can be institutionalized through layered civilian governance and industrial policy. This approach constitutes a viable middle path for states that remain deeply embedded in global production and data networks, since it reduces exposure while preserving market integration and diplomatic flexibility. By operationalizing the dual doctrines of strategic autonomy and strategic indispensability, Japan seeks to secure its digital future through domestic industrial capability and technology driven connectivity rather than through reactive escalation in great power competition. Japan recognizes structural risks, including market concentration associated with enterprises backed by the Chinese state, yet it frames its response as business continuity and disaster resilience. This framing enables substantive security outcomes, including route diversification and expansion of a cable ship fleet flagged by Japan, while sustaining the political and economic space required for continued external engagement. The comparative implication is clear. Whereas Washington leverages hub position and coercive institutional power to lock in security driven connectivity through exclusion and alliance reinforcement, Tokyo operates under spoke constraints and employs domestic institutional

power to build resilience within the network through technology driven connectivity.

4.3.3 ASEAN

ASEAN represents a distinct governance form. It is a regional organization that sits at the crossroads of major Indo Pacific routes and hosts critical landing hubs, yet it does not possess unified coercive authority or comprehensive industrial capability across cable value chains. Its central challenge is to reduce vulnerability to weaponized interdependence without undermining the openness, investment, and cooperation that sustain regional development. Regional initiatives show that ASEAN increasingly recognizes submarine cables as strategic infrastructure, but it frames the issue primarily through resilience and trusted ecosystem building. At the Fourth ASEAN Digital Ministers' Meeting in Singapore from 1 February 2024 to 2 February 2024, ministers endorsed the Singapore Declaration, which calls for a secure, diverse, and resilient submarine cable network. Related dialogues have sustained attention to maintenance, repair coordination, and the protection of landing points. This agenda reflects an emergent securitization process, but one that proceeds through developmental and resilience frames rather than through overt exclusion.

This policy posture is consistent with a structural diagnosis derived from trade and innovation indicators. ASEAN member states exhibit rising trade competitiveness in selected digital infrastructure related segments, but technological innovation capacity remains fragmented and uneven. As a result, many member states remain dependent on external suppliers and finance for system design, manufacturing, installation, and repair. In this context, hypersecuritization would impose high opportunity costs and could deepen dependence on a narrower set of external hubs by raising prices and slowing deployment. ASEAN's viable pathway is therefore strategic desecuritization oriented toward capability building and regional coordination.

A first component is regional public private partnership that integrates member state strengths and reduces information asymmetries on incidents, supply chain exposure, and repair readiness. A second component is structured cooperation with technologically advanced partners to strengthen standards, resilience planning, workforce development, and technology upgrading in ways that preserve openness while reducing high risk dependence. A third component is incremental institutionalization through ASEAN led processes that can harmonize best practices on landing station security, reporting, and repair coordination without

requiring binding supranational authority.

In this sense, ASEAN's strategy is not the absence of security politics, but a calibrated pathway that seeks to make connectivity more resilient while sustaining growth and avoiding premature securitization that would exceed regional capabilities. ASEAN's structural constraints also sharpen the stakes of weaponized interdependence and clarify why the region's most effective response is not a tighter security posture defined by isolation. Limited control over core technologies for cable design, manufacturing, installation, maintenance, and repair increases exposure to both chokepoint pressures and panopticon risks, since actors with superior technical and industrial capacity can shape supply availability, repair timelines, and the integrity of data pathways. These vulnerabilities can generate domestic pressure for more state centric protection and could encourage a rhetorical shift toward hard securitization. Yet the empirical diagnosis cautions against this direction. A turn toward hypersecuritization would likely sever or chill the very partnerships, capital inflows, and private sector participation that ASEAN requires to close its innovation gap, particularly where RTA remains uneven and concentrated in a few member states. It would also raise the cost of connectivity and slow deployment by narrowing supplier options and increasing compliance frictions, which would undermine the developmental gains ASEAN seeks from digital transformation. The combined RCA and RTA evidence therefore points to a different conclusion. ASEAN needs security through capability expansion rather than security through exclusion. In this sense, the gap between trade competitiveness and technological capacity does not validate a strategy of isolation, but instead reinforces the core argument of this paper, namely that ASEAN's most coherent pathway is strategic desecuritization that manages risk through coordination, resilience planning, and cooperative upgrading. By institutionalizing regional cooperation to reduce capability disparities among member states and by embedding security objectives within growth oriented governance, ASEAN can improve its position in the submarine cable ecosystem while preserving the openness required for long term resilience and sustainable development.

5. **Conclusion**

This article explains why allied and regionally connected actors adopt divergent security strategies in submarine cable governance despite comparable exposure to Chinese participation

across the cable value chain. The core claim is interactional. Network position and institutional power jointly shape which security practices are feasible and how they are legitimated. The United States, a hub actor with strong coercive regulatory capacity, institutionalizes hypersecuritization by routinizing continuous security review, narrowing trusted suppliers, and extending exclusion through coalition alignment. Japan, a spoke actor with strong technocratic capacity, institutionalizes strategic desecuritization by translating security into civilian economic governance and industrial policy centered on resilience, diversification, and capability building. ASEAN, a regional actor with consensus based authority and uneven capability, exhibits an emergent pathway of strategic desecuritization that prioritizes repair readiness, landing point protection, trusted cooperation, and incremental upgrading rather than binding exclusion.

The findings carry three broader implications for scholarship and policy. First, they challenge the expectation of allied convergence under shared threat exposure. Comparable concerns about covert access, supply chain disruption, and coercive leverage do not yield uniform responses because actors face different positional incentives and different institutional toolkits. Hub positions amplify the payoff of exclusion and increase the plausibility of locking in security driven connectivity through licensing, procurement, and coalition reinforcement. Spoke positions raise the economic and diplomatic costs of overt exclusion and make resilience oriented strategies more credible, particularly when industrial upgrading can be pursued through civilian legitimacy.

Moreover, the article refines debates on securitization and weaponized interdependence by showing that securitization is best observed as differentiated institutionalization. Security politics is not exhausted by speeches or categorical declarations. It unfolds through regulatory design, ministerial coordination, procurement standards, and industrial programs that gradually embed security logics into routine governance. By integrating revealed comparative advantage and revealed technological advantage with comparative process tracing, the analysis links institutional choice to capability constraints and dependence patterns that structure the risk environment.

And the comparative evidence yields a practical governance lesson for ASEAN and other spoke actors. The RCA and RTA patterns imply that the region’s vulnerability is driven less by a lack of connectivity and more by a gap between trade embeddedness and innovation capability, compounded by uneven capacity across members. In such conditions,

hypersecuritization would likely be counterproductive. It would narrow partnership options, raise the cost of deployment, and slow learning and upgrading, while offering limited leverage against actors that control key technologies and repair capacity. Strategic desecuritization offers a more coherent pathway. It embeds protection within growth oriented governance through shared resilience standards, repair coordination, information sharing, route diversification, workforce development, and structured cooperation with technologically advanced partners. The objective is not to depoliticize cable security, but to govern it in a way that preserves openness while systematically reducing high risk dependence.

Thus, future research should extend the analysis to additional cases and evaluate outcomes over time, including whether institutionalized pathways measurably reduce disruption risk, improve repair responsiveness, and shift supplier concentration. Even at this stage, the evidence supports a clear conclusion. Connectivity is becoming a contested domain, yet effective security governance depends on matching instruments to position and capacity, not on replicating a single model across structurally dissimilar actors.

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Appendix

(a)

The mathematical formulation of the RTA index is given by:

$$RTA_{c,i,t} = \frac{s_{c,i,t} / \sum_i s_{c,i,t}}{\sum_c s_{c,i,t} / \sum_c \sum_i s_{c,i,t}} \quad (1)$$

Here, the patent stock s is calculated as follows:

$$s_{c,i,t} = \sum_{k=0}^{\infty} (1-\delta)^k v_{c,i,t-k} \quad (2)$$

In equation (2) above, v represents the number of patents granted in year t for industry i. Here, δ denotes the depreciation rate of the patent stock, and it is set to 0.4 such that the weight of the corresponding patent falls below 0.0001 in the year when the 20-year patent expiration period is reached. Industry i can be listed in IPC codes in the appendix (b)

(b)

IPC Classification List for the Subsea Cable Industry

IPC code	Description
• B36B	• ships or other waterborne vessels
• B63B 35	• special-purpose vessels
• G01C 13	• hydrographic surveying
• H02G 1	• installation of electric cables or lines
• B63C 11/00	• equipment for underwater work
• E02F 3/00	• devices for dredging or soil-shifting
• E02F 5/10	• trenching machines
• F16L 1/24	• laying pipes or cables
• G02B 6/00	• optical fibers
• G02B 6/44	• optical fiber cables
• H02G 1/00	• methods or apparatus for installing electric cables or lines
• H02G 1/06	• methods or apparatus for installing cables or lines
• H02G 1/12	• submarine or underground installation
• H02G 15/00	• cable connections; cable termination processing